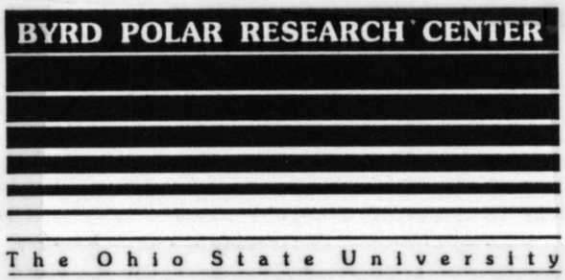
PROCEEDINGS
OF THE
FOURTH POLAR DIATOM COLLOQUIUM

DEPARTMENT OF QUATERNARY RESEARCH
STOCKHOLM UNIVERSITY

AUGUST 24 - 28, 1992



Byrd Polar Research Center Miscellaneous Series M-323
Fourth Polar Diatom Colloquium Proceedings

BYRD POLAR RESEARCH CENTER
The Ohio State University
Columbus, Ohio 43210, USA

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BYRD POLAR RESEARCH CENTER
THE OHIO STATE UNIVERSITY
COLUMBUS, OHIO 43210
USA

Organizing Committee:
Urve Miller
Anders Wasell
Amy Leventer

Includes:
Agenda
Abstracts
Attendee List

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Compiled in 1993 by the
BYRD POLAR RESEARCH CENTER

This report may be cited as:

Leventer, A. (ed.), 1993. *Proceedings of the Fourth Polar Diatom Colloquium, Department of Quaternary Research, Stockholm University, Stockholm, Sweden, August 24-28, 1992.* BPRC Misc. Series M-323, Byrd Polar Research Center, Columbus, 72 pp.

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ACKNOWLEDGMENTS

We would like to thank the following:

1) **Swedish Natural Science Research Council** - for financial support of the travel and accommodation costs for the invited lecturers and the secretary, and for grants given for the East European and South American participants.

2) **The Department of Quaternary Research, Stockholm University** - for supporting the organization of the Colloquium and being the host institute.

3) **The Polar Committee at the Royal Academy of Sciences and Polar Secretariat** - for the study visit and the reception at the Academy.

4) **The Museum of Natural History, the Departments of Botany and Palaeobotany** - for the kind presentation of the Cleve and Kolbe diatom collections and files, and for showing the participants the Polar exhibition.

5) **The Staff of the Askō Marine Biological Field Station and the leadership of the Marine Centre of Stockholm University** - for letting us be the first guests in the new rooms.

6) **Kristina Edstrōm and her daughter, Isabel** - who prepared the delicious food we had the pleasure of enjoying in their company during the Colloquium at Askö.

7) **Kathleen Doddroe of the Byrd Polar Research Center** - for extensive support in the preparation of this volume.

ABSTRACT

The Fourth Polar Diatom Colloquium was hosted by the Department of Quaternary Research, Stockholm University, on August 24-28, 1992. Dr. Urve Miller and Anders Wasell were responsible for all local organization and funding; Dr. Amy Leventer organized the scientific program. The meeting was held at the Field Station of Marine Biology of Stockholm University. The meeting consisted of both microscopic and thematic sessions.

The microscope work concentrated on

(1) assessing the alteration of diatom assemblages via post-mortem processes in both the Arctic and Antarctic, and

(2) diatom evolution in the Antarctic spanning the lower Cretaceous to present.

The thematic sessions focused on

(1) modern diatom distribution as a function of environmental variability,

(2) the use of modern analogs in interpreting the sedimentary record, and

(3) taxonomic, evolutionary, and biostratigraphic concepts in diatom work.

These proceedings contain abstracts of all the talks presented at the meeting, as well as summaries of the microscopic sessions and lists of participants at this and other polar diatom colloquia.

PROGRAM

Monday, August 24

9-10 AM

Registration and coffee welcome at Department of Quaternary Research followed by an introduction to the meeting and a lunch break

Afternoon

Visit Museum of Natural History with Cleve and Kolbe diatom collections and Polar Exhibition

Afternoon/Evening

Welcome Party - Swedish Academy of Sciences

Tuesday, August 25

Afternoon Session

Microscope Session #1 - Leader: Rita Horner
"Arctic - Alteration of Diatom Assemblages via Post-mortem Processes"

Wednesday, August 26

Morning Session

Microscope Session #2 - Leader: Amy Leventer
"Antarctic - Alteration of Diatom Assemblages via Post-mortem Processes"

Afternoon Session

Discussion Session #1 - Leader: Heinz Klöser
"Modern Distribution Data"

Thursday, August 27

Morning Session

Discussion Session #2 - Leader: Michèlle De Sève
"Use of Modern Analogs to Understand Paleoenvironmental Records"

Afternoon Session

Microscope Session #3 - Leader: David Harwood
"Diatom Evolution in the Antarctic: Lower Cretaceous to Present"

Evening Session

"Diatom Dinner"

Friday, August 28

Morning Session

Microscope/Discussion Session #4 - Leader: David Harwood
"Diatom Evolution in the Antarctic: Lower Cretaceous to Present" - Continued

Afternoon Session

Discussion Session #3 - Leader: David Harwood
This session covered a variety of different topics including biostratigraphy, taxonomy, and new methods and techniques.

MICROSCOPE SESSIONS

Two microscope sessions (Arctic and Antarctic) were devoted to demonstrating the changes in diatom assemblage that occur as diatoms are transferred from the living to death assemblage. During both sessions we focused on observing and understanding the bias introduced into the assemblages as a result of the post-mortem processes of advection, dissolution, and grazing. Samples from the sea ice, water column (niskin bottles, tows, sediment traps), and surface and downcore sediments were available from various regions of the Arctic and Antarctic. Appendix I summarizes the species composition of the Arctic samples.

Samples from Antarctica were contributed by Lloyd Burckle (RC13-271, 7-meter Holocene core from 52° S), Grethe Hasle (net haul samples from 54° S in the subantarctic Pacific), Cecilie Hellum (Weddell Sea samples from both open water and sub-ice net hauls, melt pools, sub-ice threads, and sea ice), Rita Horner, Heinz Klöser (samples extracted from sponges and ascidians from Maxwell Bay on King George Island), and Amy Leventer (samples from sea ice, sediment traps and surface sediments from McMurdo Sound, and downcore samples from the George V Coast and Prydz Bay). Appendix II is a summary of the samples provided by Amy Leventer.

For the final microscope session, David Harwood provided sets of slides to familiarize us with the evolution of diatoms in the Antarctic. Slides from the Ross Sea and Kerguelen Plateau were utilized to demonstrate evolutionary changes in lineage and taxonomy. Species of stratigraphic importance are illustrated in Appendix III.

SESSION 1: Modern Distribution Data

Leader: Heinz Klöser

Speakers: *(in alphabetical order)*

A SHORT DESCRIPTION OF DIFFERENT ALGAL ASSEMBLAGES IN AN ANTARCTIC MARGINAL ICE ZONE

Cecilie Hellum
The Norwegian College of Fishery Science

Material and methods

The study area extended from open water of the northeastern Weddell Sea to an area covered with ice from Prinsesse Astrid Kyst and westwards to Halley Station. Between 5 January and 26 February, 1990 sampling was carried out in different regions with variating ice conditions. The sampling was a part of the Norwegian Antarctic Research Program 1989/90 (NARE 1989/90).

Vertical net samples were taken both in areas with and without ice. Ice algae were also collected from the underside of the ice, from pools and from melted ice.

Relative abundances of diatoms in cleaned slides were calculated.

Results

Most often *Fragilariopsis cylindrus* was the dominating species, both in the net samples and the ice samples. Its variation was then from 15.31% - 84.82%. The lowest occurrence was in a sample from open water where no species were particularly frequent. One of the reasons for the high dominance of *F. cylindrus* compared to the second most common species, is that *F. cylindrus* is very small and therefore easily come up with high numbers.

There were other species than *F. cylindrus* dominating in some of the samples, both from open water and from areas with ice (Table 1).

Big differences in algal composition were also found within small distances, both between close vertical net samples along the underside of the ice, but also between net samples below the ice, vertical net samples and ice samples.

There was a bigger component of pennate diatoms in areas with ice than without. This was also the case when comparing samples from net hauls along the underside of the ice or different ice samples with the vertical net hauls in the same area.

Table 1. An overview of dominating species found during the NARE 89/90 cruise to the Weddell Sea (cleaned samples).

Species	Highest relative occurrence, %	Habitat
Fragilariopsis cylindrus (Grunow) Krieger	84.82	Vertical net, no ice
	80.71	Vertical net, ice
	79.87	Horizontal net, below ice
	83.75	Melted ice
	56.24	Threads
	78.68	Pools
Fragilariopis curta (Heurck) Hustedt	76.86	Melted ice
Berkeleya adelienses Medlin	87.41	Threads
Chaetoceros dichaeta Ehrenberg	46.21	Vertical net, no ice
Nitzschia lecointei Van Heurck	44.62	Horizontal net, below ice
	48.31	Threads
Synedropsis recta (Hasle et. al, are describing this)	53.25	Horizontal net, below ice
Manguinea sp.	58.41	Horizontal net, below ice
Dictiocha speculum Ehrenberg	32.61	Vertical net, no ice

Phaeocystis pouchetii was the dominant non-diatom species both in areas with and without ice and was dominating in some of the samples.

Phaeocystis pouchetii (Hariot) Lagerheim	+++	Vertical net, no ice
	+++	Vertical net, ice
	+++	Horizontal net, below ice
	+++	Infiltration layer

IMPORTANCE OF *FRAGILARIOPSIS CYLINDRUS* IN THE ANTARCTIC MARGINAL ICE ZONE

Sung-Ho Kang

Department of Oceanography, Texas A & M University

The marginal ice edge zones are now widely recognized as a major site of increased phytoplankton biomass and primary productivity throughout the year, and the diatoms in the ice-edge zones are an important constituent of the Antarctic flora. Planktonic diatoms were sampled in the ice-edge zone of the Bellingshausen Sea during the early austral spring of 1990 and of the Weddell Sea during the late spring of 1983, the autumn of 1986, and the winter of 1988. The four cruises in the Antarctic marginal ice edge zones, combined with the summer cruise in Prydz Bay during a brief ice-free period (1988) provided us with opportunities for spatial and seasonal studies of diatom abundance and distribution in the water column.

Bacillariaceae (including genus *Fragilariopis, Nitzschia, and Cylindrotheca*) was predominant diatom family, accounting for 42% - 88% of the total diatoms through our five cruises near marginal ice-edge zones. Especially *Fragilariopsis cylindrus* was a major component in the family Bacillariaceae and was the single most important contributor for diatom increases in the marginal ice-edge zones throughout the seasons. Although the nanoplanktonic pennate diatom *F. cylindrus* has been reported as a very important species in the water column in coastal and ice-edge zones, it had not been reported as a principal ice-edge diatom species until featured by Kang and Fryxell (1992) and Kang et al. (1992). The average integrated abundance of *F. cylindrus* from the five cruises was about 35% of the total diatom abundance. The highest numbers of *F. cylindrus* cells were found during the summer. During the spring and autumn the average integrated absolute numbers of *F. cylindrus* cells were similar, and during the winter the lowest *F. cylindrus* cell density was observed in ice-edge water columns. However, during the summer *F. cylindrus* cell density was about 20 times more abundant than during the spring and autumn and about 700 times more abundant than during the winter.

The overall spatial patterns of spatial patterns of *F. cylindrus* abundance within the marginal ice zones during all seasons revealed a similar trend, having low abundances under the pack ice relative to open water maxima near the ice edge zones. Seasonal differences of *F. cylindrus* cell density between ice-covered waters and open waters near the ice edge were similar during the spring (1 - 1.4-fold differences) but were more different during other seasons relative to those of the spring (3 - 7) times higher in the open waters).

Sung-Ho Kang (cont'd.)

Cluster analysis using integrated absolute abundance (cells m^{-2}) of five Bacillariaceae species and groups as variables showed the stations not only separated based on seasons and cruises, but they also separated based on location of stations in the ice edge (open water stations vs. ice-covered stations).

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BENTHIC DIATOM COMMUNITIES AT POTTER COVE (KING GEORGE ISLAND, SOUTH SHETLANDS).

Heinz Klöser

Netherlands Institute of Ecology

Benthic diatoms have been found to be important contributers to primary production and to the food web in the coastal Antarctic ecosystem. They can be used as tracers in studies on hydrography, sedimentation dynamics and transfers of organic matter. However, to do this, the original communities of the diatoms must be well known. An investigation on benthic diatom communties was started in the austral summer 1991/1992 in Potter Cove, a fjord-like inlet with a great variety of different habitats. A number of communities could be distinguished, which are related to different types of substrate. However, the principal separation of communities did not follow the classical scheme of epilithic, epiphytic, epipsammic communities, but rather reflected structural properties of the substrates and frequency of disturbance.

In the sublittoral for example, two communities on hard substrates were present: Flat structures like smooth stone and rock as well as foliose thalli of macroalgae (i.e. *Iridea, Gigartina* and others) and cauloids of *Desmarestia* were mainly colonized by flat-shaped *Cocconeis and Amphora* species. In contrast, prostrate structures like bushy macroalgae (i.e. *Picconiella, Pantoneura, Plocamium, Ballia, Halopteris,* phylloids of *Desmarestia*) and certain bryozoan colonies carried diatoms with stalked, fanshaped colonies like *Licmophora* and *Rhoiosphenia,* which could also occur on stones with a rough surface. This community often, but not always, contained the upright band-shaped colonies of *Entopyla australis* and *Achnanthes simplex.* Only, when these species were present, sometimes, *Arachnoidiscus ehrenbergii* additionally was found. This latter species almost completely was restricted to plants of *Ballia callitricha,* to old basal parts of cauloids of *Plocamium cartilagineum* and arborescent bryozoans. A preliminary explanation for the differentiation of the two communties may be, that the crucial factor may be the degree of shelter versus exposition. In the second community, possibly a succession takes place from an initial widespread *Licmophora* stage to the final appearance of *Arachnoidiscus.* The latter would then indicate the most stable and persistent microhabitats.

Diatom mats developed on the soft bottom, which were dominated by several *Gyrosigma* species, accompanied by several other species (*Navicula directa,* several *Nitzschia* species, *Pinnularia quadratarea*, *Barcleya* spec., *Tabularia* spec.) Pelagic species like *Corethron criophilum* were abundant, but obviously in bad condition or dead. Some other species, which are well know as ice algae (*Entomoneis kufferathii, Nitzschia stellata)* were also present in low numbers, these being in good condition. The whole community was repeatedly buried by sediment, but reestablished itself after short periods again. Thus, the members of this community had to be highly mobile to be able to move to the new surface. In the same general habitat, several species of *Amphora* colonized the tunicae of ascidians, where they were protected from burial by sediments. It is doubtful whether this can be regarded as a community of its own, as *Amphora* was also abundant on flat, hard substrates.

In three isolated places, which have little in common (an ascidian, a *Plocamium cartilagineum* in ambient light and a *Delesseria lancifolia* shadowed by a dense *Desmarestia* canopy), a further community was noted: It was made up of arborescent colonies of *Isthmia enervis,* in which aggregations of *Triceratium arcticum* grew.

The interidal has been devoid of diatoms due to intensive grazing by limpets and turbellarians, except the tidepools. Small tidepools in the upper intertidal contained almost pure *Melosira nummuloides,* while in small tidepools in the lower intertidal tube-dwelling *Navicula* spec. and *Berkeleya* spec. as well as *Melosira charcotii* occured. Big tidepools have again been devoid of diatoms, but in otherwise barren tidepools of medium size, some macroalgae-like thalli of tube dwelling diatoms were found. This conspicuous form may be closly related (if not identical) to *Navicula (Parlibellus) delognei* from the Northeast Atlantic (Lobban 1989).

It should be noted, that all information given in this paper is highly preliminary and needs confirmation. Reinvestigation of the same habitats during the coming season (austral summer 1992/1993) will show which of the data are reliable and which probably reflect only ephemeral phenomena.

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DISTRIBUTION OF ANTARCTIC DIATOMS IN DIFFERENT HABITATS AND ITS IMPORTANCE AS FOOD FOR KRILL

Ryszard Ligowski

Department of Invertebrate Zoology and Hydrobiology,
Laboratory of Polar Biology, University of Lódz

The presented paper is based on the studies of diatom samples collected during five Polish Antarctic Expeditions carried out in the western part of the Atlantic sector of the Antarctic during the years 1981-1989.

The aims of the study were:

1. to distinguish diatom taxa distribution in the study area;
2. to determine natural habitats of diatom taxa found in the diet of krill and, on that basis;
3. to find food sources of krill in open-sea and near-shore areas.

Part of these results were already published (Kopczynska and Ligowski 1982, 1985; Ligowski 1982, 1986, 1988, 1992; Ligowski and Kopczynska 1992).

Altogether, 650 diatom samples were considered (including 236 samples of planktonic diatoms, 121 samples of sea ice diatoms, 125 samples of sessile diatoms and 168 samples from krill stomachs). Two hundred seventy-eight diatom taxa were identified in the samples. In water column, 234 diatom taxa were recognized, in the sea ice - 161, on the sea bottom - 159 taxa and, in food of krill - 106 taxa.

In the water column, there were 13 main dominant taxa, 12 diatom species: *Chaetoceros atlanticus, Ch. criophilus, Ch. dichaeta, Ch. neglectus, Ch. socialis, Ch. tortissimus, Corethron criophilum, Nitzschia* (*Delicatissima* complex), *Nitzschia* (*Fragilariopsis* complex), *Proboscia alata, Rhizosolenia antennata* f. *semispina, Thalassiosira antarctica*, and, the only species not belonging to diatoms, *Phaeocystis pouchetii*.

On the basis of some envioronmental data (salinity, temperature, depth to the bottom, day of the growth season, content of chlorophyll *a,* density of cells) characteristic features in the distribution of dominant species were established.

Ryszard Ligowski (cont'd.)

Using Principal Component Analysis, the position of the dominating species in water column in relation to principal components I and II was plotted taking into account the percentage of samples with dominating species. These groups of species can be distinguished:

1. *Corethron criophilum* and *Phaeocystis pouchetii*;

2. *Thalassiosira antarctica* and small species of *Chaetoceros (neglectus, socialis* and *tortissimus);*

3. species of *Chaetoceros* with big cells: *atlanticus, criophilus, dichaeta, Nitzschia (Fragilariopsis* complex and *Delicatissima* complex), *Proboscia alata* and *Rhizosolenia antennata* f. *semispina.*

The position of dominating species using abiotic factors (salinity, temperature, soundings to the bottom, day of the season) is similar (except *Corethron criophilum* and *Phaeocystis pouchetii)* as in the former plotting.

Stepwise regression analysis indicates that only the sounding depth is correlated with average cells density and average content of chlorophyll *a* for dominating species. At the dominance of *Chaetoceros socialis, Ch. neglectus, Ch. tortissimus, Thalassiosira, antarctica* and *Phaeocyctis pouchetii* chorophyll *a* content and cell density were higher than average values. In the case of dominance of *Corethron criophilum, Proboscia alata, Nitzschia* (*Delicatissima* complex), *Nitzschia* (*Fragilariopsis* complex), *Rhizosolenia antennata* f. *semispina, Chaetoceros criophilus, Ch. dichaeta* and *Ch. atlanticus* the values of chlorophyll *a* and density of of phytoplankton cells were lower than average.

Content of organic C in plankton and benthic diatoms from krill diet in the Admiralty Bay indicates that planktonic diatoms prevail in the summer season. From May to the beginning of October organic C of benthic diatoms orgin prevailed, however, the total content of organic C was low. Also, at some stations in open sea a rather high share of benthic diatoms in krill diet was found.

Summarizing, one can suggest that in the near-shore ecosystem and somethimes also in open-sea, bottom and epiphytic diatoms can play an important role as food or krill particularly in winter season with scarcity of phytoplankton.

Ryszard Ligowski (cont'd.)

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SEASONAL CHANGES IN THE ABUNDANCE AND SPECIES COMPOSITION OF PLANKTONIC DIATOMS AT AN ANTARCTIC COASTAL SITE

Harvey J. Marchant

Australian Antarctic Division

Changes in the species composition and abundance of planktonic diatoms in coastal waters near the Australian Antarctic station of Davis were followed together with changes in the concentrations of the prymnesiophyte *Phaeocystis,* bacteria, choanoflagellates and particulate and dissolved organic material as well as water temperature and ice conditions (Davidson and Marchant 1992). The detailed investigation was carried out in the 1988/89 summer and compliments other summer and year-round investigations carried out in this area over the last decade (Perrin et al. 1987, Walker and Marchant 1989, Marchant and Perrin 1990). For most of the year the concentration of diatoms in the water column was extremely low. A maximum concentration of 6×10^6 cells l^{-1} was reached. The colonial form of *Phaeocystis pouchetti* is the first major phytoplankton species to bloom reaching a peak concentration of 6×10^7 cells l^{-1} in early January. Various diatoms proliferated at different times during the summer. *Entomoneis kjellmanii,* a major component of the sea ice community, peaked in early December and was seen for the rest of the summer. Nanoplanktonic *Nitzschia* spp. concentration, which was often comprised largely of *N. pseudonana,* reached their maximum coinciding with declining sea-ice cover and may have been released from the sea-ice. *Nitzschia closterium* was exceptional among the diatoms in that it reached maximum concentration during the bloom of *Phaeocystis.* The concentration of *N. curta* and morphologically similar chain-forming diatoms grouped within the species *N. seriata* increased in concentration from late December and attained maximum abundance in mid January, immediately followed by *Nitzschia curta. Nitzschia seriata* and *N. curta* were the major constituents of the diatom bloom. The minor constituents of the diatom assemblage, *Chaetoceros dichaeta, C. neglectum* and *C. simplex,* were the major constituents of the diatom bloom. The minor constituents of the diatom assemblage, *Chaetoceros dichaeta, C. neglectue* and *C. simplex,* were most abundant during the *Phaeocystis* bloom. *Nitzschia cylindrus, Rhizosolenia* spp. and *Nitzschia frigida* contributed to the assemblage after the *Phaeocystis* peak.

Harvey Marchant (cont'd.)

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EFFECT OF UV ON THE GROWTH AND SURVIVAL OF ANTARCTIC MARINE DIATOMS - IMPLICATIONS FOR COMMUNITY STURCTURE

Harvey J. Marchant
Australian Antarctic Division

Spring-time depletion of stratospheric ozone over Antarctica has become a major environmental issue as it has been suggested that the resulting increase in UV-B (280-320 nm) irradiation may adversely affect Antarctic marine ecosystems. Numerous investigations have demonstrated a diminution of phytoplankton productivity under ambient and elevated levels of UV, yet other studies have found little or no such inhibition. In Antarctic waters the impact of elevated UV exposure is equivocal despite a number of investigations. El-Sayed et al. (1990) concluded that any UV irradiation reduced primary productivity. Smith et al. (1992) found that primary production was reduced by at least 6-12% under the Antarctic ozone hole and that there was some interspecific variability in phytoplanktonic response to UV exposure. Karentz et al. (1991) also showed substantial interspecific differences in survival of Antarctic diatoms following UV-B exposure. We too have demonstrated marked interspecific differences in the survival and productivity of different diatom species when exposed to UV under laboratory conditions as well as in field studies. Whether these differences could lead to changes in phytoplankton species composition remains to be ascertained.

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CHANGES IN DIATOM ABUNDANCE IN THE FAST ICE OF THE DAVIS AND COSMONAUT SEAS DURING THREE WINTERS

Vladimir A. Nikolaev

Botanical Institute - St. Petersburg

A comparative analysis of the fast ice diatom abundances at Mirny (1968) and Molodezhnaya (1969, 1977) stations, was carried out.

Preliminary analysis of diatoms cell abundances showed that there are autumn and spring maxima.

High quantities of diatoms in April and May is caused by great variety of species and high amount of cells in the water masses before and during the ice formation period. Apparently in the upper and lower horizons of young ice, diatom vegetation is continued.

In June the diatom abundance in fast ice is diminished considerably, possibly because of dissolution of diatom frustules frozen into the ice in April and May, and migration of algae with the transport of brine.

From August the abundance of diatoms cells in upper and especially lower horizons increases and reaches its maximum in November. In the middle horizons of ice the diatom abundance remains low.

The dynamics of the diatom cell abundances in fast ice at the Mirny and Molodezhnaya stations has a synchronous character with some abnormal exceptions in June and July.

DIATOM ASSEMBLAGES FROM THE WEDDELL AND THE ATLANTIC SECTOR OF THE SOUTHERN OCEAN

Uli Zielinski

Alfred-Wegener Institute for Polar and Marine Research

Siliceous hardparts and diatoms are important components in the sediments of the Southern Ocean. Diatom assemblages from surface sediments reflect the hydrology of the overlying surface waters. Owing to their variability and their widespread occurrence in the Southern Ocean, diatoms are useful tools in reconstruction of paleoenviromental conditions in past oceans.

After examination of 174 surface samples covering an area from the Subtropical Front to the Filchner-Rønne Ice Shelf in the Weddell Sea, four important diatom species and species groups (*Nitzschia curta, N, cylindrus, N. kerguelensis, Eucampia antarctica,* resting spores of the genus *Chaetoceros*) were selected in order to present their distribution patterns in present day surface sediments.

The distribution of ice algae (*Nitzschia curta, N. cylindrus*) is closely related to the extension of sea ice. The northernmost occurrence is present between the maximum and mean winter sea ice distribution around 55° S. In the shelf areas of the Weddell Sea ice algae dominate the assemblages in excess of 50% relative abundance. In this area, resting spores of *Chaetoceros* are also present, with abundances up to 40-60%. Between the Polar Front and the Subtropical Front their occurrence diminishes to below 10% relative abundance. *N. kerguelensis* dominates (>80%) the diatom assemblages in the deep sea areas of the Weddell Sea. The distribution of this species over the oceanographic fronts in quite uniform at 40 to 60%. In the neritic environments, which are influenced by sea ice during most of the year, *N. kerguelensis* is a minor component of the assemblages (<5%). The mean relative abundance of *E. antarctica* ranges from 2 to 5% in the study area. Highest abundances (12%) occur near the Polar Front and off the Rønne Ice Shelf. In the Weddell Sea, the distribution pattern of *E. antarctica* is patchy and show a high variability.

In order to relate present diatom assemblages to the surface water hydrology (e.g. temperature, salinity, nutrients) transfer functions were established after the technique described by Imbrie and Kipp (1971). Q-mode factor analyses of the raw data reveal no clear relationships between diatom assemblages and surface water temperature. After transformation into a classification system and four abundance classes ("ranking") according to Pichon et al. (1987, 1992), the data result in four factors, which can be related more closely with the hydrographic conditions in the surface water than the raw data. Multiple regression analyses result in low standard errors of estimate. The correlation coefficients for temperature and salinity are higher than 0.98, the value for the phosphate concentrations reaches 0.96.

SESSION 2: Use of Modern Analogs to Understand Paleo-environmental Records

Leader: Michèlle De Sève

Speakers: *(in alphabetical order)*

GENERAL SUMMARY

Michèlle De Sève

A number of questions arise when it comes to using modern analog to explain downcore assemblages:

1) How are diatom assemblages transformed from the water column phytoplankton to the surface sediments?

2) How representative of paleoenvironments and paleoproductivity are the diatom records?

In the presentations given, it was shown that surface phytoplankton assemblages differ from what is observed in the surface sediments (e.g., Frobisher Bay and the Labrador Sea). In the sediments, the number of species is less than in the surface water phytoplankton and some species disappear (ex. *Fragilaria* sp. and *Coscinodiscus oculus-iridis* in Frobisher Bay) while others appear (ex. *Coscinodiscus marginatus* in the Gulf of St. Lawrence and the Labrador Sea). Some of the factors considered were 1) restricted blooms in time and space (ex. ice-associated algae which are not found in the sediments (ex. *Fragilaria* sp.), 2) differential dissolution of silica frustules (thickly silicified diatom are favored (ex. *Thalassiothrix longissima, Thalassiosira antarctica* resting spores).

Despite these changes in species assemblages from surface phytoplankton down to surface sediments, the diatoms that remain in the sediments can be used as modern analogs to understand paleoenvironmental events providing that sufficient information is known about the present ecological status of the diatom species. Illustration of the use of modern diatom analogs to understand past paleoenvironmental events was provided from the Eurasian Arctic Shallow Seas study and from the Granite Harbor, Antarctica study.

The use of sediment traps in determining seasonal patterns of flux and species composition in relation to surface currents and upwelling was well demonstrated for the Guinea Basin.

Important Note: *Thalassiosira gravida* Cl. resting spores had been identified as one of the dominant diatom species in sediment samples from the Gulf of St. Lawrence, the Labrador Sea and Frobisher Bay. Upon the recommendation of Dr. Grethe Hasle, this species identification was changed to *Thalassiosira antarctica* resting spores on the basis that: 1) *T. gravida* has, so far, never been seen to form resting spores and, 2) the distribution of the strutted processes.

THE DECLINE OF MICROPALEONTOLOGY

Lloyd H. Burckle
Lamont-Doherty Geological Observatory

Micropaleontology had its earliest application in the petroleum industry; because of their microscopic size and high species diversity, microfossils proved to be the fastest, cheapest and most reliable way to assign relative ages to sediments. As such, they were a key tool in the study of subsurface geology. Subsequently, it was demonstrated that microfossils were extremely reliable in determining ecology, particularly discrete depths in shallow water environments. This also had considerable commercial application, most notably in the oil industry. In the post World War II era, particularly the interval from 1950-1980, microfossils increasingly came into use as important indicators of past ecology; indeed, beginning in the late 1960's, mathematical applications, largely appropriated from the social sciences, were successfully used to reconstruct past sea surface temperatures in sediments of late Quaternary age. The successful CLIMAP program used temperature equations, derived from the implied relationship between microfossil assemblages in surface sediments and summer and winter surface water temperatures, to estimate sea-surface temperatures during the Last Glacial Maximum.

The future also seemed bright for stratigraphic micropaleontology; beginning in the 1960's, the use of magnetostratigraphy, and to a lesser extent, $\delta^{18}O$, greatly increased the resolving power of microfossil first and last appearances and made it possible for them to tell both relative and absolute time. The use of microfossils to tell time or to reconstruct surface water paleoceanography probably reached its nadir in the late 1970's or early 1980's. After that geophysical and geochemical applications increasingly took over the roles previously filled by micropaleontology: seismic stratigraphy, sequence stratigraphy, magnetic reversal and magnetic susceptibility stratigraphy, $^{87}Sr/^{86}Sr$ stratigraphy, $\delta^{18}O$, $\delta^{13}C$ and $(Ge/Si)_{opal}$, were all used to determine a relative and, in many cases, an absolute chronology. Of special significance was the fact that many of these measures could be applied to questions of past subsurface circulation as well as past ocean chemistry. In my view, the decline of micropaleontology as an applied discipline is directly related to the rise of other methods for addressing questions of chronology and paleoenvironment; questions which previously were almost the sole province of micropaleontology. While the

Lloyd H. Burckle (cont'd.)

CLIMAP program relied heavily on micropaleontology with stable isotopes as an ancillary and largely chronostratigraphic tool, the succeeding SPECMAP program relied heavily on modeling, stable isotopes and other geochemical measures; in many respects, micropaleontology was a minor contributor.

Much of this shift can be attributed to advances in the earth sciences; as the field evolves, new ways of telling time and environment are tested and applied. However, some of the decline is the responsibility of the micropaleontologist. While geochemists and paleoceanographers have learned and applied new techniques to questions concerning chronology, climate and oceanography, many micropaleontologists are still using techniques developed in the early post-World War II era. If the current trend continues, micropaleontologists will find sole employment with the Ocean Drilling Program (ODP) and the value of microfossils will reside exclusively in the stable isotopes and trace elements found in their shells. In spite of this pessimistic outlook, I feel that there is room for micropaleontology to answer questions of chronology and the past behavior of oceans. This cautious optimism is based upon some recent trends in micropaleontology: sediment trap data to determine the oceanographic conditions dictating the occurrence of species or groups of species (C. Sancetta, A. Leventer); quantitative biostratigraphy (P. Boden); further refinement of microfossil transfer functions (N. Koc Karpuz, U. Zielinski); the use of diatoms to trace past bottom and intermediate water flow (U. Treppke); the application of evolutionary models to diatoms (U. Sorhannus, E. Fenster). These are only some of the recent applications of diatom micropaleontology. I expect more. However, the new diatom micropaleontologists must be better grounded in such fields as mathematics, geochemistry and oceanography.

DIATOM ASSEMBLAGES IN SURFACE SEDIMENTS FROM THE GULF OF ST. LAWRENCE (CANADA): PRELIMINARY RESULTS

Martine Lapointe
GEOTOP, Université du Québec à Montreal

The Gulf of St. Lawrence is a highly-stratified semi-enclosed sea which comprises a wide range of environmental conditions from estuarine to oceanic. This transitional marine environment is characterized by a strong gradient of salinity (20 to 34‰) and of temperatures (summer surface: 8 to 15°C) and by important seasonal variations (in winter the surface temperature drops to -1°C).

In order to define the relations between diatom assemblages and sea-surface conditions (temperature, salinity, ice cover, etc.), 29 surface-sediment samples have been analyzed. More than 100 taxa have been identified, most of them to the species level. The most common species are: *Coscinodiscus bathyomphalus (Bacteriosira fragilaris* resting spores), *Thalassiosira antarctica* resting spores, *Porosira glacialis, Thalassiosira nordenskioeldii, Chaetoceros* spp., *Navicula* spp., *Aulacoseira* spp. and *Nitzschia* spp.

Based on the ecology and the environmental conditions, 40 groups of diatoms were formed. A cluster analysis performed on these 40 groups, revealed two distinct assemblages, related to salinity gradient. The first one defined by *Cyclotella meneghiniana* and *Stephanodiscus astrea* is characteristic of estuarine conditions. The second assemblage composed of *Paralia sulcata, Thalassiosira nordenskioeldii, Coscinodiscus marginatus* and *Thalassiosira antarctica* resting spore assemblage represents more open marine conditions (although still epicontinental).

On these grounds, the diatom analysis of Postglacial sequences should recognize possible overflow of fresh water during the last deglaciation in the Gulf of St. Lawrence. A transfer function, based on the diatom analysis, will be ultimately developed and used to reconstruct the evolution of the Gulf of St. Lawrence surface water since the last glacial episode (about 18,000 years ago).

HIGH RESOLUTION RECORD OF LATE HOLOCENE OCEANOGRAPHIC AND DEPOSITIONAL CHANGES FROM GRANITE HARBOR, ANTARCTICA

Amy Leventer

Byrd Polar Research Center, The Ohio State University

Downcore diatom data from cores retrieved from deep basins located in Granite Harbor, Antarctica, provide new, high-resolution information concerning changes in oceanographic and depositional processes that have occurred during the last 1250 years. Long-term changes in floral assemblages, as recorded by changes in the relative concentration of *Nitzschia cylindrus*, reveal the influence of global scale climatic change, during the time of the Medieval Warm Period and possibly the Little Ice Age, on this region. Temporally, Granite Harbor experienced less annual and pack ice cover during both these periods, probably because of stronger offshore winds during the Little Ice Age and higher temperatures during the Medieval Warm Period. The sedimentary record reveals distinct, short-lived events in which nearly monospecific blooms of *Corethron criophilum* and *Chaetoceros* spp. occur. These events were possibly the result of strong stabilization of the upper water column and were most likely a response to regional, rather than global conditions. However, these types of events may play a significant role in the delivery of organic carbon and biogenic silica to the sea floor.

HOLOCENE DIATOM ASSEMBLAGES OF THE EURASIAN ARCTIC SHALLOW SEAS AS STRATIGRAPHIC MARKERS AND AN INDICATOR OF PALEOENVIRONMENTAL RECORDS

Y.I. Polyakova

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Holocene assemblages have been studied in sediment cores raised from all the Eurasian-arctic shallow seas, e.g., the Chukchi and East-Siberian Seas, the southeastern part of Laptev Sea and Western Kara Sea, and the eastern Barents Sea.

Six ecological diatoms zones, distinguished by the common quantity of diatom valves per gram of dry sediments and the percentage ratios of the diatom ecological groups have been used to divide the cores into sections. For the purpose of estimating the age of diatom ecological zones, radiocarbon dates for Eurasian shelf sediments, global sea-level curves, and the estimated rates of sedimentation in different parts of arctic seas have been used.

Late Pleistocene Ecozone VI is characterized by low taxonomic diversity of diatom assemblages, extremely low abundance of cryophilic and sublittoral marine species and relatively high abundance of fresh-water species in some regions. The absence of relatively warm-water species which would have been transported to the western and eastern parts of the Eurasian Arctic Shelf with the North Atlantic Ocean and Bering Sea currents, was a function of decreased warm-water penetration to the arctic seas at the end of the Late Pleistocene when the sea level was lower than now.

The Holocene diatom assemblages coinciding the Ecozone V and IV formed between 12-10 KY B.P. and 6-5 KY B.P. and reveal the influence of rising sea level and increasing penetration of relatively warm-water North Atlantic and North Pacific currents to the Arctic seas.

The stratigraphic marker diatom assemblage coinciding the Holocene Ecozone III is characterized by the largest number of diatom valves per gram of dry sediments and the appearance of diverse warm-water species in the Chukchi and Barents Sea. This suggests that the most favorable oceanographic conditions for the diatom flora occurred during the Holocene and a sharp increase of primary productivity was

caused by changing water mass circulation in the arctic seas. This Holocene paleoenvironmental event was displayed in all Eurasian Arctic Seas during the time nearest 5.5 and 2.5 KY B.P. and named "Hydrobiological optimum" in order to distinguish it from the Holocene climatic optimum recorded earlier in the terrestrial environment.

The diatom assemblages of Ecozone II indicate colder water than today and diatom assemblages of Ecozone I most resemble the diatom thanatocoenoses in the uppermost layer of the arctic seas sediments.

LABRADOR SEA PHYTOPLANKTON AND SURFACE SEDIMENT DIATOM ASSEMBLAGES

Michèle De Sève
(Independent Consultant)

A total of 73 surface sediment samples (box cores and trigger weight cores) were analyzed for diatom composition. The aim was to compare the distribution of the diatom assemblages from the surface sediment with those of surface water (0 to 50 m) phytoplankton diatom assemblages. Phytoplankton assemblages were determined from samples collected inshore of the West Greenland Current (water depth 157 m), offshore of the West Greenland Current (water depth 3400 m) and in the Labrador Current (water depth 2522 m).

From the surface water phytoplankton samples, two principal diatom assemblages were determined: 1) the "West Greenland Current" assemblage with the dominant diatom species *Chaetoceros decipiens, Rhizosolenia hebetata f. semispina, Thalassiothrix longissima,* and the sub-dominant *Chaetoceros atlanticus* and *Rhzosolenia styliformis*, and 2) the Labrador Current assemblages with *Thalassiosira antarctica* (vegetative cells and resting spores), *T. nordenskioeldii, Nitzschia cylindrus, N. grunowii, Chaetoceros debilis* and *Chaetoceros socialis.*

The dominant diatom species composing the surface sediment assemblages included: *Chaetoceros* sp., *Coscinodiscus marginatus, Thalassiosira antarctica* (resting spores), *T. nordenskioeldii* and *Thalassiothrix longissima.* The spatial distribution of these surface sediment diatoms were in good agreement with the distribution of the surface water diatom assemblages, except for *Thalassiosira nordenskioeldii* and *Coscinodiscus marginatus* which was not recorded in the phytoplankton.

SEASONAL FLUX OF PLANKTONIC DIATOMS IN THE GUINEA BASIN

Ute Treppke

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The diatom content of sediment trap samples collected in the Guinea Basin from March 1989 through March 1990 was analyzed. The sediment traps were located both north of the equator (GBN: 1°47'N, 11°07'W) and south of it (GBZ4: 2°10'S, 9°54'W). At site GBN3 the water depth was 4481 m, with sampling depths of 853 m and 3921 m. At site GBZ4 the water depth was 3921, with sampling at a depth of 696 m. The cone-shaped traps had 20-cup collectors and a collection are of 0.5 m^2. Samples were poisoned with $HgCl_2$ and cleaned with $KMnO_4$ and HCl. Analyses were carried out on 1/64 splits of the total material in the trap. Daily flux rates were calculated and the results were compared with biogenic opal and total fluxes (Wefer and Fischer, Deep Sea Res., in prep.).

Fluxes in the study area were related to seasonal shifts on the Inter Tropical Convergence Zone (ITCZ) and associated variations with the trade wind system. At the northern Guinea Basin site (GBN3), highest total fluxes occurred during August and September, a period characterized by the strongest southern trades and the northernmost displacement of the ITCZ. At the southern site in the central Guinea Basin (GBZ4), total flux was highest during March to May, after the ITCZ had reached its southernmost position and during the maximum influence of the northern trades. This is also the time of highest sea surface temperatures.

The flux pattern of diatoms followed biogenic opal and total flux, with highest values in March and April and a second peak in August/September. The spring flux showed a strong coastal influence with high abundances of freshwater and coastal species, and phytoliths occurring together with the normal oceanic summer peak was related to upwelling which induced a significant increase of the dominant species *Nitzschia bicapitata*. Summer upwelling did not affect site GBZ4 as much as GBN3, so that at this site high fluxes were restricted to March-May due to the strong coastal influence. *Fragilariopsis kerguelensis* occurred only in the GBZ4 trap in July, marking the northernmost displacement of the subantarctic species by the Benguela Current.

A total of about 200 taxa were identified. Diatom species composition and abundance variations throughout the year allowed the recognition of five assemblages: (1) Coastal upwelling, (2) Oceanic upwelling, (4) Mixed, and (5) Coastal. *Nitzschia*

bicapitata was the dominent species throughout the entire year, with relative abundance ranging between 28 and 84%.

At GBN3, the diatom flux of the lower trap followed the flux pattern of the upper trap with some smoothing and a time lag of about two months.

The analysis of the diatom content of sediment trap samples from the Walvis Ridge has been started. So far, only the diatom flux of the spring samples (March-June) from the upper trap (sampling depth: 599 m, water depth: 2196 m) has been determined. The total flux and the opal flux increased from March to the end of May. During this time the diatom flux also increased, and the diatom assemblages changed significantly from sample to sample. The lithologenic input increased very rapidly from the end of April to June. During this time *Amphora* sp. showed high relative abundances. During April the relative abundance of *Fragilariopsis kerguelensis* increased strongly, possibly due to a southerly influence of the Benguela Current and/or transport mechanism of the intermediate water.

COMPARISON OF WATER COLUMN AND SEDIMENT SAMPLES FROM SOUTHEAST CANADIAN ARCTIC AND FROBISHER BAY

Kerstin Williams

Institute of Arctic and Alpine Research, University of Colorado

Matching samples from water column and bottom sediment were collected during ice break-up in an east-west transect from near-shore areas of the inner parts of Frobisher Bay in the northeastern Canadian Arctic. Great differences were found in the expected diatom composition of the sediments as compared to the overlying water column. Although *Fragilaria* sp. A was present in high concentrations in the water column, it was essentially not found in the sediment. *Coscinodiscus oculus-iridis* was also very common in the spring bloom, and occurred very rarely in the sediment samples. Explanations for this include 1) that some diatom blooms may represent a very brief period of time compared to other species blooms, thus the signal gets too diluted to be detectable, 2) a very pronounced pycnocline develops in spring during ice melt, which may be partly responsible for lack of diatom preservation, 3) changes in photosynthesis produces changes in pH, which may facilitate dissolution or preservation, 4) zooplankton grazing, 5) mechanical abrasion of the diatom frustules, set up by the vigorous tidally induced currents and 6) diatom populations might follow non-linear dynamics and thus very small changes in initial conditions, beginning at ice-melt, may have a very great impact on species composition such that rarely do we get identical blooms from year to year.

SESSION 3: Biostratigraphy, Taxonomy, Methods

Leader: David Harwood

Speakers: *(in alphabetical order)*

RELATIVE ABUNDANCE OF EUCAMPIA ANTARCTICA TRACKS $\delta^{18}O$ AND $\delta^{13}C$ IN LATE QUATERNARY SEDIMENTS OF THE SOUTHERN OCEAN

Lloyd H. Burckle
Lamont-Doherty Geological Observatory

While $\delta^{18}O$ and $\delta^{13}C$ chemostratigraphy and AMS ^{14}C chronostratigraphy are applied in sediments of late Quaternary age in the Subantarctic region and around the Polar Front Zone (PFZ), it is difficult to date sediments further to the south. Instead, stratigraphies based upon changes in relative abundance of single species have been used with the implication that such changes are directly related to glacial/interglacial conditions. This lack of a coherent stratigraphic correlation between the antarctic and subantarctic regions has hampered our efforts to produce synoptic views of the Southern Ocean during the Last Glacial Maximum (LGM) and the deglacial and to address questions dealing with past distribution of seasonal sea ice, sea surface temperature and water mass fronts. One of the relative abundance stratigraphies used in late Quaternary sediments both north and south of the PFZ is that of the diatom *Eucampia antarctica*. While this stratigraphy was directly tied to $\delta^{18}O$ and $\delta^{13}C$ records in cores north of the PFZ, correlation to a similar record south of the PFZ was based entirely upon curve matching and pattern recognition. In recent years, however, it has become possible to do stable isotopes on small samples, thus permitting us to extend southward the range of stable isotope stratigraphy. We have found that the relative abundance stratigraphy of *E. antarctica* tracks $\delta^{18}O$ and $\delta^{13}C$, and that this is true for regions both north and south of the PFZ and for the Atlantic and Indian sectors of the Southern Ocean; we have no data as yet from the Pacific sector. The *E. antarctica* relative abundance stratigraphy can be used, therefore, as a proxy for $\delta^{18}O$ and $\delta^{13}C$ in higher southern latitudes where no biogenic carbonate is preserved. This is true not only for the level of the LGM, but also for levels extending as far back as our record; oxygen isotope stage 12.

DISCUSSION ABOUT SOME TAXONOMIC PROBLEMS IN SPECIES OF THE GENUS *RHIZOSOLENIA*

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The genus *Rhizosolenia* Brightwell, an important member of marine phytoplankton communities, has been revised recently by Sunström (1986). It comprises a large and complex group of species, of which *R. antennata* (Ehrenberg) Brown, *R. hebetata* (Bailey) and *R. clevei* Ostenfeld are discussed in the present paper. The main goal of this paper is to call attention to similarities among these species, which could lead to confusion in identification. A revision of the "*antennata - hebetata - clevei*" complex, is needed.

Identifications of these taxa are based on the shape of the valve, processes and structure and distribution of the girdle bands.

Based on our own observations of some of the species and revisions in the literature (Table 1), we can see that there are more morphological similarities between *R. antennata f. semispina* Sundström and *R. hebetata g. semispina* (Hensen) Gran than between the former species and *R. antennata*, as well as between *R. hebetata f. semispina* and *R. hebetata*.

Comparing morphological characters of the forms and the variety with their respective species, we find that *R. hebetata f. semispina* does not share any of the mentioned characters with *R. hebetata*. It is almost indistinguishable (LM-SEM) from *R. antennata f. semispina* from which it is only geographically separated.

Therefore, we should first consider if the diagnostic characters used to separate these taxa are good enough to keep these taxa the way they are, and then consider their distributional pattern.

It is important to put in doubt the relationship among these "complex" taxa in order to clarify relationships within species or between species clusters. We think more research is needed using material from different parts of the world.

Table 1. Morphometic and Distributional Data on the *Rhizolenia* Species

MORPHOMETRIC DATA		*R. antennata*	*R. hebetata*	*R. clevei*	*R. antennata f. semispina*	*R. hebetata f. semispina*	*R. clevei var. communis*
valve							
L.M.	process	2	1	1	1	1	1
	ø(mm)	18-45	15-44	80-200	6.5 - 42	4.6 - 25	7 - 55
	Otaria -Shape -extending along basal part of process (µm)	lacking -- --	lacking -- --	present no pointed 4	present pointed 3	present pointed 3	present no pointed 5
TEM	areolae [close to peak] # of slits vela [close to margin]	▮ ▮ ▮	? 	▮ 	▮ ▮ ▮	▮ ▮ ▮	▮
Girdle	# of columns of segments	2	2	more than two	2	2	2
Copulae TEM	# of slits in vela	▮ ▮	▮	▮	▮ ▮	▮ ▮	▮
	# of areolae (µm)	23 - 26	?	18 - 23	23 - 26	28 - 30	19 - 26
	# of columns (µm)	24 - 26		18 - 22	24 - 26	30 - 32	14 - 22
Distribution		Antarctic	Arctic (Boreal)	Tropical Subtropical	Antarctic	Arctic (Boreal)	Tropical Subtropical

Sundström (1986), Hasle (1975), Medlin-Priddle (1990), Okuno (1967)

COMPARISON OF DIATOM ABUNDANCES BETWEEN FILTERING (HPMA) AND SETTLING (UTERMÖHL) TECHNIQUES

Sung-Ho Kang

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Traditionally, quantitative studies of diatom abundance and distribution have relied on the Utermöhl sedimentation method of concentrating cells; the absolute abundances of smaller-celled diatoms (<20 μm), lightly silicified cells, and empty frustules might have been underestimated if the cells remained unsettled or were destroyed by the preservative. The classical Utermöhl method is still one of the most widely used methods for quantitative analyses of phytoplankton, but this method shows many disadvantages compared to a newly described membrane filter mount technique with water-soluble resin (HPMA, 2-hydroxypropyl methacrylate) using filtered samples by Crumpton (1987): 1) Long settling time is required and it cannot be used on board ship. 2) A suitably equipped inverted microscope is required. 3) Resolution is limited by the low numerical aperture of long working distance condensers. 4) It does not provide a permanent record of the sample.

When the filtering technique was compared to the settling method for its ability to give quantitative cell-density estimates of natural water samples collected in Prydz Bay, East Antarctica (Kang and Fryxell, 1991), the filter technique was found to be superior to the settling method for smaller-celled diatoms such as *Fragilariopsis cylindrus* and *Cylindrotheca closterium* (= *Nitzschia closterium*) and all empty cells which are assumed to be dead when collected (Kang, 1989; Kang and Fryxell, 1989). But the filtering technique for larger-celled diatoms such as *Corethron criophilum, Chaetoceros dichaeta, Thalassiosira* sp. etc., gave results similar to those obtained using the Utermöhl settling method.

In addition to simplicity, economy, and suitability for use at sea, the filtering technique offers unique advantages over the Utermöhl method: 1) Resulting mounts are relatively permanent at least four years under our storage condition, and thus provide a long-term record of the sample. 2) The technique is more suitable for making accurate quantitative estimates of nanoplanktonic diatom that can be distinguished by morphological characteristics on a light microscope using multiple optical modes of contrast. 3) Preparation allows accurate quantitative analysis of diatom on board ship.

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PARMALES - POSSIBLE PROGENITORS OF THE DIATOMS?

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Nanoplanktonic siliceous cysts of unknown taxonomic affinity have been reported from cold water environments since the late 1970s. It was speculated that these organisms could be the resting stage of loricate choanoflagellate protozoa. An ultrastructural investigation revealed that these organisms are algae and unlikely to be a resting stage. Finding the presence of three thylakoid lamellae, a girdle lamella and chloroplast endoplasmic reticulum together with a silica wall indicated that they are most appropriately assigned to the Chrysophytes (Marchant and McEldowney, 1986). The formal taxonomy of these organisms was reported by Booth and Marchant (1987) creating the new order Parmales comprising three new genera, the monospecific *Triparma* and *Pentlamina* and *Tetraparma*, which contains five species and four subspecies. On the basis of similarities in the walls of Parmales and diatoms it has been proposed that the Parmales may be the closest extant relatives of the diatoms and exemplify a stage in diatom evolution (Mann and Marchant, 1989).

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CHANGES IN MORPHOLOGY OF TWO COSCINODISCUS SPECIES

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Coscinodiscus centralis Ehrenberg and *C. oculus iridis* gathered in 1973-1989 at the different regions of the Southern Ocean were examined with SEM.

The research was aimed at the elucidation of possible morphological alteration of areola's vela, which directly gets into touch with the environment, and supposedly is the most plastic element of frustule.

The morphological changes of cribella's cribral pores construction and the slim siliceous membrane closing the valvae are revealed.

In spite of the vast amount of examined material, the data are insufficient to elucidate the reasons of alteration. It is possible to assume two factors in force: morphogenetic factors causing the consistence of the cribra and its elements formation, and an ecological one, causing the changes of these elements under the influence of the environment.

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APPENDIX I

Species Composition of Arctic Samples and Selected References

Cecilie Hellum *Kerstin Williams*
Rita Horner *Michèlle De Sève*

LABRADOR SEA (* dominant species)

PHYTOPLANKTON:

Station I:
West Greenland Current inshore
(1 June 1990; depth 157 m)

**Nitzschia cylindrus* (Grun.) Hasle
**Nitzschia delicatissima* Cl.
**Nitzschia grunowii* Hasle
**Thalassiosira gravida Cl.* + spores
**Thalassiosira nordenskioeldii* Cl.
Achnanthes taeniata Grun. (?)
Chaetoceros debilis Cl.
Chaetoceros decipiens Cl.
Chaetoceros furcellatus Bail.
Chaetoceros socialis Laud.
Coscinodiscus centralis Ehr.
Coscinodiscus oculis-iridis Ehr.
Melosira binderana Kütz.
Nitzschia longissima (Bréb.) Grun. cf.
Nitzschia polaris Grun.
Thalassiosira hyalina (Grun.) Gran

Station II:
West greenland Current offshore
(5 June 1990; depth 3400 m)

**Chetoceros decipiens* Cl.
**Rhizosolenia hebetata f. semispina* (Hens.)
**Thalassiothrix longissima* Cl. & Grun.
Chaetoceros atlanticus Cl.
Chaetoceros convolutus Castr.
Chaetoceros debilis Cl.
Rhizosolenia styliformis Bright.
Thalassiosira nordenskioeldii Cl.
Thalassiosira gravida Cl.

Station III:
Labrador Current
(13 June 1990; depth 2522 m)

**Chaetoceros convolutus* Castr.
**Rhizosolenia hebetata f. semispina*
Chaetoceros borealis Bail.
Nitzschia delicatissima Cl.
Nitzschia grunowii Hasle
Thalassiothrix longissima Cl. & Grun.

Labrador Current
(Buchanan & Foy 1980)
**Thalassiosira gravida* Cl.
**Thalassiosira nordenskioeldii* Cl.
** Nitzschia cylindrus*
** Nitzschia grunowii* Hasle
** Chaetoceros debilis*
** Chaetoceros socialis* Laud

SEDIMENTS (surface) :
**Chaetoceros sp.1* (C. decipiens ?)
**Coscinodiscus marginatus* Ehr.
**Thalassiosira gravida* Cl. (spores)
**Thalassiosira nordenskioledii* Cl. (spores)
**Thalassiothrix longissima* (Grun.) Cl. *
Actynocyclus Erenbergii (Ralfs) Pritch.
Actynoptychus splendens (Shadb.) Ralfs
Asteromphalus robustus Castr.
Biddulphia aurita (Lyngb.) Bréb.
Chaetoceros atlanticus Cleve
Chaetoceros decipiens Cleve
Chaetoceros diadema (Ehr.) Gran
Chaetoceros furcellatus Bail. , spores
Chaetoceros sp.2 (setae of C. convolutus or C. borealis)
Cocconeis arctica Cl.
Cocconeis placentula Ehr.
Coscinodiscus bathyomphalus Cleve
Coscinodiscus curvatulus (Grun.) Schmidt (= *Actinocyclus curvatulus* Jan.)
Coscinodiscus oculus-iridis Ehr.
Hantzschia marina (Donk.) Grun.
Navicula directa (Smith) Ralfs in Pritch.
Nitzschia cylindrus (Grun.) Hasle
Nitzschia frigida Grun.
Paralia sulcata (Ehr.) Cl.
Porosira glacialis (Grun.) Jørg.
Rhabdonema arcuatum (Lyng.) Kutz.
Rhizosolenia hebetata f. *hebetata* Bail.
Rhizosolenia hebetata f. *semispina* (Hens.) Gran
Rhizosolenia styliformis Bright.
Rhopalodia gibberula (Ehr.) O. Müll.
Thalassionema nitzschioides Grun.
Thalassiosira eccentrica (Ehr.) Cl. (T. trifulta Fryxell)
Thalassiosira oestrupii (Ostenf.) Proshkina Lavenko

DOWNCORE (Labrador 021, depth 1200 m)

*Chaetoceros sp.1 (C. decipiens ?)
*Coscinodiscus marginatus
*Thalassiosira eccentrica
*Thalassiosira gravida
*Thalassiosira nordenskioeldii
*Thalassiothrix longissima
Chaetoceros decipiens
Chaetoceros diadema
Chaetoceros furcellatus
Coscinodiscus oculus-iridis
Gramathophora sp.1
Nitzschia frigida
Paralia sulcata
Rhizosolenia styliformis
Rhopalodia sp.1

Phytoplankton and ice algae found in Arctic samples. x = present; + = dominant; * = 2% or more.

SPECIES	Beaufort Sea (Horner) PHYT	Beaufort Sea (Horner) ICE	Resolute (Hellun) PHYT	Resolute (Hellun) ICE	Frobisher Bay (Williams) PHYT	Labrador Sea (De Seve) PHYT	Labrador Sea (De Seve) ICE	Barents Sea (Hellun) PHYT	Barents Sea (Hellun) ICE	Barents Sea (Williams) ICE + WATER
Achnanthes hyperborea Grunow					*					*
Achnanthes kryophila Petersen										x
Achnanthes taeniata Grunow	x	x	x			x		x		
Achnanthes sp.	x									
Actinocyclus curvatulus Janisch	x									*
Actinocyclus Ehrenbergii (Ralfs) Pritchard							x			
Actinoptychus undulatus (Bail.) Ralfs	x									
Actinoptychus splendens (Shadb.) Ralfs							x			
Amphiprora hyperborea				x				x	x	
Amphora ocellata Donkin	x	x								
Amphora sp.	x									
Asterionella kariana Grunow	x									
Asterosphalus robustus Castracane							x			
Bacterosira fragilis Gran	x		+					+		
Berkeleya rutilans			x							
Caloneis cilicula (Ehr.) Cleve										x
Caloneis oregonica (Ehr.) Patarick										*
Caloneis sp. A										x
Chaetoceros affinis Lauder	x									
Chaetoceros atlanticus Cleve	x		x			x	x			
Chaetoceros borealis Bailey	x					x				
Chaetoceros brevis Schütt	x									
Chaetoceros compressus Lauder	x									
Chaetoceros compressus spores	x									
Chaetoceros concavicornis Mangin	x		x					x		
Chaetoceros convolutus Castracane	x					+				
Chaetoceros curvisetus Cleve			x							
Chaetoceros danicus Cleve	x									
Chaetoceros debilis Cleve	x		x			x		x		
Chaetoceros decipiens Cleve	x		+			+	x	x		
Chaetoceros diadema (Ehr.) Gran (as Ch. subsecundus (Grun.) Hustedt)	x		+				x			
Chaetoceros diadema spores	x									
Chaetoceros didymus Ehrenberg	x									
Chaetoceros fragilis Meunier	x									
Chaetoceros furcellatus Bailey	x		x			x	x	++		
Chaetoceros furcellatus spores	x									
Chaetoceros gracilis Schütt	x	x								
Chaetoceros holsaticus Schütt	x									
Chaetoceros ingolfianus Ostenfeld	x									
Chaetoceros ingolfianus spores	x									
Chaetoceros karianus Grunow	x									
Chaetoceros laciniosus Schütt			x					x		
Chaetoceros nitra (Bail.) Cleve spores	x		x					x		
Chaetoceros radicans Schütt	x									
Chaetoceros septentrionalis Ostrup	x	x	x					x		
Chaetoceros similis Cleve	x									
Chaetoceros simplex Ostenfeld	x									
Chaetoceros socialis Lauder	x		+++			x		++		
Chaetoceros subtilis Cleve	x									
Chaetoceros teres Cleve	x		x							

SPECIES	Beaufort Sea (Horner) PHYT	ICE	Resolute (Hellum) PHYT	ICE	Frobisher Bay (Williams) PHYT	Labrador Sea (De Seve) PHYT	ICE	Barents Sea (Hellum) PHYT	ICE	Barents Sea (Williams) ICE + WATER
Chaetoceros wighami Brightwell	x		x					x		
Chaetoceros phaeoceros spp.	x									
Chaetoceros misc. spores	x				‡					x
Chaetoceros spp. tiny	x									
Chaetoceros spp. medium	x									
Chaetoceros spp. large	x									
Chaetoceros spp.	x	x					+	x		
Cocconeis arctica Cleve							x			
Cocconeis placentula Ehrenberg							x			
Cocconeis sp.	x				‡					
Coscinodiscus cf. bathyomphalus Cleve							x			x
Coscinodiscus centralis Ehrenberg	x					x				
Coscinodiscus curvatulus Grunow							x			
Coscinodiscus marginatus Ehrenberg	x						+			
Coscinodiscus oculus-iridis Ehrenberg	x				‡	x	x			
Coscinodiscus perforatus Ehrenberg cf.	x									
Coscinodiscus radiatus Ehrenberg	x							x		
Coscinodiscus spp.	x									
Cyclotella sp.	x									
Cylindrotheca closterium (Ehr.) Reimann & Lewin (as Nitzschia closterium (Ehr.) W. Smith)	x	x		x				x		‡
Detonula confervacea (Cleve) Gran	x									
Diploneis litoralis v. arctica Cleve										x
Diploneis spp.	x		x							x
Entomoneis paludosa v. hyperborea (Grun.) Poul. & Cardinal (as Amphiprora paludosa v. hyperborea (Grun.) Cleve)	x	x								
Entomoneis spp. (as Amphiprora sp.)	x	x								
Eucampia zodiacus Ehrenberg	x									
Eucampia groenlandica Cleve			+							
Eunotia spp.		x								x
Fragilaria pinnata Ehrenberg					‡					x
Fragilaria spp.		x	x	x	‡			x		x
Fragilariopsis cylindrus			++	++				+++	x	
Fragilariopsis oceanica			+++	+++				+++	x	
Gomphonema spp.	x									
Gomphonemopsis exigua (Kütz.) Medlin (as Gomphonema exiguum Kützing	x	x								
Gomphonemopsis pseudoexigua (Simonsen) Medlin					‡					
Gyrosigma cf. arcticum										‡
Gyrosigma fasciola (Ehr.) Griffith & Hendey	x	x								
Gyrosigma spp.								x		x
Gyro-Pleurosigma spp.	x	x								
Hantzschia marina (Donk.) Grunow							x			
Haslea crucigeroides (Hust.) Simonsen				x				x		
Landera cf. annulata Cleve										x
Landeria sp. A										‡
Leptocylindrus danicus Cleve	x		x							
Leptocylindrus minimus Gran	x									
Leptocylindrus sp.	x									
Licmophora spp.	x	x		x						
Melosira ambigua (Grun.) O. Müller										x
Melosira arctica (Ehr.) Dickie	x		x							‡

SPECIES	Beaufort Sea (Horner) PHYT	Beaufort Sea (Horner) ICE	Resolute (Hellum) PHYT	Resolute (Hellum) ICE	Frobisher Bay (Williams) PHYT	Labrador Sea (De Seve) PHYT	Labrador Sea (De Seve) ICE	Barents Sea (Hellum) PHYT	Barents Sea (Hellum) ICE	Barents Sea (Williams) ICE + WATER
Melosira binderana Kützing						x				
Melosira distans (Ehr.) Kützing										x
Melosira juergensi Agardh	x									
Melosira spp. cf.	x				x					
Navicula bolleana (Grunow) Cleve cf.	x	x								
Navicula crucigera (W. Sm.) Cleve										x
Navicula debilissima Grunow	x									
Navicula directa (W. Sm.) Ralfs	x	x	x		x	x		x	x	x
Navicula forcipata Greville										x
Navicula gelida Grunow	x							x	x	
Navicula granii			x							
Navicula inviolata Hustedt										x
Navicula cf. kariana (Grun.) Cleve										x
Navicula kjellmanii Cleve	x	x								
Navicula lyroides Hendey	x									
Navicula maculosa Donkin	x	x								
Navicula marina Ralfs	x	x								
Navicula pediculus Cleve	x									
Navicula pelagica Cleve	x	x	x					x		
Navicula recurvata Gran	x									
Navicula septentrionalis			x					x		
Navicula sibirica (Grun.) Cleve	x		x					x		
Navicula spicula (Hickie) Cleve		x								
Navicula superba Cleve								x	x	
Navicula transitans Cleve	x	x						x	x	cf
Navicula transitans v. derasa (Grun.) Cleve	x									
Navicula trigonocephala Cleve	x	x								
Navicula valida Cleve & Grunow	x	x								
Navicula vanhoeffenii				x				+	+	
Navicula spp.		x	x	++	x			x	x	
Neidium spp.										x
Nitzschia angularis W. Smith	x	x								
Nitzschia brebissonii v. borealis Cleve			x							
Nitzschia cylindrus (Grun.) Hasle	x	x			x	+				x
Nitzschia frigida Grunow	x	x	++	+		+		x	++	x
Nitzschia grunowii Hasle	x				x	+				x
Nitzschia laevissima Grunow								x	x	
Nitzschia longissima (Breb.) Grunow cf.	x					x				
Nitzschia neofrigida Medlin			x					x	x	
Nitzschia cf. ovalis Arnott										x
Nitzschia polaris Grunow				x		x		x	x	cf
Nitzschia promare Medlin								x	+	
Nitzschia cf. pusilla					x					
Nitzschia ribbons	x									
Nitzschia signa (Kütz.) W. Smith	x									
Nitzschia signoidea (Nitzsch) W. Smith	x	x								
Nitzschia tryblionella Hantzsch										x
Nitzschia vanhoffenii Gran										
Nitzschia spp. tiny (possibly Nitzschia cylindroformis Hasle)	x									
Nitzschia spp.	x	x		x	x					x
Odontella aurita Ag.	x						x	x		
Opephora aff. gennata (Grun.) Hustedt					x					
Paralia sulcata (Ehrb.) Cleve	x		x				x			

SPECIES	Beaufort Sea (Horner)		Resolute (Hellum)		Frobisher Bay (Williams)	Labrador Sea (De Seve)		Barents Sea (Hellum)		Barents Sea (Williams)
	PHYT	ICE	PHYT	ICE	PHYT	PHYT	ICE	PHYT	ICE	ICE + WATER
Pinnularia interrupta W. Smith										x
Pinnularia quadratarea (Schmidt) Cleve		x			s					
Pinnularia quadratarea v. kerguelensis (Cl. & Grun.) C	x	x								
Pinnularia quadratarea v. theelii (Cleve) Cleve	x	x								
Pinnularia spp.	x		x							
Pleurosigma "clevei"			x					x	x	
Pleurosigma stuxbergii			x					x	x	
Pleurosigma stuxbergii v. rhomboides (Cl.) Cleve								x	x	
Pleurosigma spp.			x		s					
Porosira glacialis (Grun.) Jorgensen	x		x	x	s		x	+	x	x
Pseudogomphonema arcticum (Grun.) Medlin								x	+	s
(as Gomphonema exiguum v. arctica (Grun.) Cleve)	x									
Pseudogomphonema kamtschaticum (Grun.) Medlin										
(as Gomphonema kamtschaticum Grunow)	x									
Pseudonitzschia delicatissima (Cleve) Heiden	x	x	x					x		
(as Nitzschia delicatissima Cleve)	x					+				
Pseudonitzschia seriata (Cleve) Hasle	x	x	+					x		
Pseudonitzschia seriata v. obtusa (Hasle) Hasle			+	x				x	x	
Rhabdonema arcuatum (Lyng.) Kützing							x			
Rhabdonema spp.					s					
Rhizosolenia alata Brightwell	x									
Rhizosolenia fragilissima Bergon	x									
Rhizosolenia hebetata (Bail.) Gran							x			x
Rhizosolenia hebetata f. semispina (Hensen) Gran	x		x			+	x	x		s
Rhizosolenia setigera Brightwell	x									
Rhizosolenia styliformis Brightwell	x					x	x			
Rhizosolenia spp.	x									
Rhoiconeis sp.	x									
Rhopalodia gibberula (Ehr.) O. Müller							x			
Skeletonema costatum (Grev.) Cleve	x									
Stauroneis anceps v. subcapitata Ostrup										s
Stauroneis granii Jorgensen	x									
Stauroneis quadripedis (Cleve-Euler) Hendey	x	x								
Stauroneis sp.	x									
Surirella spp.										s
Synedra cf. capucina					s					
Synedra hyperborea								x		
Synedra tabulata Kützing			x		s			x		
Synedra spp.		x							x	
Thalassionema nitzschioides (Grun.) Van Heurck	x				s		x			
Thalassiosira anguste-lineata (A. S.) Fryxell & Hasle			x							
(as Thalassiosira polychorda (Grun) Jorgensen)	x									
Thalassiosira antarctica Comber	x				s					
Thalassiosira antarctica v. borealis Fryx., Donc. & Hubb.			+++					+		
Thalassiosira cf. baltica (Grun.) Ostenfeld										s
Thalassiosira bioculata (Grun.) Ostenfeld			+					x		
Thalassiosira bulbosa Syvertsen								+		
Thalassiosira constricta Gaarder								x		
Thalassiosira decipiens Cleve	x									x
Thalassiosira eccentrica (Ehr.) Cleve	x						x			
Thalassiosira gravida Cleve	x	x	+	x	s	+				x
Thalassiosira gravida Cleve spores						+	+			x
Thalassiosira hispida Syvertsen								x		
Thalassiosira hyalina (Grun.) Gran	x		x	x	s	x		+++	x	

SPECIES	Beaufort Sea (Horner) PHYT	Beaufort Sea (Horner) ICE	Resolute (Hellum) PHYT	Resolute (Hellum) ICE	Frobisher Bay (Williams) PHYT	Labrador Sea (De Seve) PHYT	Labrador Sea (De Seve) ICE	Barents Sea (Hellum) PHYT	Barents Sea (Hellum) ICE	Barents Sea (Williams) ICE + WATER
Thalassiosira kushirensis Takano								x		
Thalassiosira nordenskioeldii Cleve	x		+++	x	+	+	+	x		
Thalassiosira oestrupii (Ostenf.) Hasle							x			
Thalassiosira spp. tiny (<10u)	x									
Thalassiosira spp. medium (10.5-29.5u)	x									
Thalassiosira spp. large (30-75u)	x									
Thalassiothrix longissima Cleve & Grunow			x			+	+			
Thalassiothrix spp.	x	x								
Tropidoneis spp.	x	x								x

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APPENDIX II

Species Composition of Antarctic Samples

Amy Leventer

DIATOM SLIDES

Several pre-made slides illustrating diatom assemblages from several regions of the Antarctic, from several different environments are available. You are welcome to take these slides home with you. Below is a short description of the assemblages and a brief list of the major species you should be able to identify in each sample.

Samples 1, 2, and 3 are all from Granite Harbor, in northwestern McMurdo Sound. Note the large differences in the samples as a function of the specific environment they represent.

1. DF89 WG24 0-1 cm (727 m water depth) and DF89 WG45 0-1 cm (856 m water depth) surface sediment samples from Granite Harbor (McMurdo Sound)

These samples illustrate a typical high latitude shelf assemblage from a region covered by annual sea ice for approximately 10-11 months each year. The assemblage is dominated by *Nitzschia curta*, but other species of this genus are common also, including *Nitzschia angulata, Nitzschia cylindrus, Nitzschia kerguelensis, Nitzschia obliquecostata, Nitzschia ritscheri,* and *Nitzschia separanda.* Some *Chaetoceros* spores are present, as are a low percentage of species from the genus *Thalassiosira.* Most common of these is *Thalassiosira antarctica.*

The key characteristic to note is the high proportion of pennates to centrics, typical of an area with extensive sea ice cover.

2. McMurdo Ice Algae - from the bottom 20 cm of congelation ice in Granite Harbor

Typically an ice algal assemblage is dominated by a few species. This sample represents ice algae combined from several samples of melted sea ice. The dominant species include *Amphiprora* spp. (two species), *Navicula* spp. (several species), *Nitzschia stellata, Pinnularia quadratarea, Pleurosigma* sp., and *Tropidoneis* sp.

Nitzschia curta is also commonly found in the sea ice (despite its absence in these samples). Note the difference in assemblage composition between the sea ice and the underlying surface sediments described in #1. This difference is largely the result of dissolution of the very fragile sea ice diatoms.

3. K042 '88-'89 VII
sediment trap sample from underneath sea ice in Granite Harbor (McMurdo Sound)

This samples was recovered from a sediment trap which had been deployed for a year in a region which is covered by sea ice for about 11 months each year. Although this sample does contain a large percentage of pennates (*Nitzschia curta, Nitzschia angulata, Nitzschia cylindrus, Nitzschia kerguelensis, Nitzschia obliquecostata, Nitzschia ritscheri,* and *Nitzschia separanda.*), it also contains a surprisingly large percentage of centrics, especially *Thalassiosira antarctica.* Many of these centrics were advected into Granite Harbor from areas of open water.

4. PC302 and DF79-12 (807 m water depth)
downcore samples from two cores from the George V Coast

These slides illustrate an assemblage from a lower latitude coastal site. Although superficially similar to the surface sediments from Granite Harbor, several differences are obvious. First, *Nitzschia kerguelensis* is much more common. This species, which appears to have two forms in these samples, is commonly found in areas bathed by Antarctic Circumpolar Water. Secondly, note increased abundance of *Nitzschia angulata* and *Nitzschia separanda*, the introduction of *Azpeitia tabularis, Thalassiosira oestrupii*, and the substitution of *Porosira glacialis* for *Porosira pseudodenticulata.*

5. Tanaya Bay 1 and 2 and Ellis Fjord
surface sediment samples

These samples are from surface sediments in the Prydz Bay region. Like #1 and #4, this is a coastal site, although a much shallower setting. The main difference to note is the increased presence of benthic diatom species - including *Cocconeis* spp., *Diploneis* spp., *Navicula* spp., and *Trachyneis* spp.

Site	DFD79-12	Tanaya Bay	Ellis Fjord
Depth	downcore	surface	surface
Acnanthes spp.		x	x
Actinocyclus actinochilus	x		
Amphiprora spp.			x
Asteromphalus spp.	x	x	
Azpeitia tabularis	x		
Chaetoceros spp. veg	x	x	
Chaetoceros spp. rs	x	xx	xx
Cocconeis spp.		x	x
Corethron criophilum			
Coscinodiscus spp.			x
Diploneis spp.		x	
Eucampia antarctica	x	x	x
Fragilaria islandica		x	x
Navicula spp.		xx	x
Nitzschia angulata	x	x	x
Nitzschia curta	x	xx	xx
Nitzschia cylindrus	x	x	x
Nitzschia kerguelensis	x	x	
Nitzschia obliquecostata	x	x	x
Nitzschia ritscheri	x	x	x
Nitzschia separanda	x		
Nitzschia stellata		x	
Nitzschia sublinearis	x		
Nitzschia turgiduloides	x		
Odontella spp. rs			
Pinnularia quadratarea		x	x
Pleurosigma sp.			x
Porosira glacialis	x		
Porosira pseudodenticulata			x
Rhizosolenia spp.	x		
Stellarima microtrias veg	x		
Stellarima microtrias rs	x		
Thalassiosira antarctica	x	x	x
Thalassiosira gracilis	x		
Thalassiosira lentiginosa	x	x	
Thalassiosira oestrupii	x		
Thalassiosira oliverana	x		
Thalassiosira ritscherii			
Thalassiosira tumida	x	x	
Tropidoneis spp.			
silicoflagellates	x	x	x

Major species of diatoms in samples, xx=abundant, x= common

Site	DF89 WG24	DF89 WG 45	McMurdo	K042 '88-'89	PC302
Depth	0-1 cm	0-1 cm	ice algae	sed. trap	downcore
Acnanthes spp.					
Actinocyclus actinochilus	x	x		x	x
Amphiprora spp.			xx	x	
Asteromphalus spp.	x			x	x
Azpeitia tabularis					x
Chaetoceros spp. veg					x
Chaetoceros spp. rs	x	x		x	x
Cocconeis spp.				x	
Corethron criophilum	x	x			x
Coscinodiscus spp.					x
Diploneis spp.					
Eucampia antarctica	x	x		x	x
Fragilaria islandica	x	x	x		
Navicula spp.			x	x	x
Nitzschia angulata	x	x		x	x
Nitzschia curta	xx	xx		x	x
Nitzschia cylindrus		x			x
Nitzschia kerguelensis	x	x			x
Nitzschia obliquecostata	x	x		x	x
Nitzschia ritscheri	x	x		x	x
Nitzschia separanda	x	x		x	x
Nitzschia stellata	x		xx	x	
Nitzschia sublinearis	x	x			x
Nitzschia turgiduloides					x
Odontella sp.				x	
Pinnularia quadratarea	x	x	x	x	
Pleurosigma sp.		x	xx	x	
Porosira glacialis					x
Porosira pseudodenticulata	x	x	x	x	
Rhizosolenia spp.	x	x			x
Stellarima microtrias veg		x		x	
Stellarima microtrias rs	x	x		x	x
Thalassiosira antarctica	x	x	x	xx	x
Thalassiosira gracilis	x	x		x	x
Thalassiosira lentiginosa	x	x		x	x
Thalassiosira oestrupii					x
Thalassiosira oliverana	x	x	x	x	x
Thalassiosira ritscherii					x
Thalassiosira tumida	x	x		x	x
Tropidoneis spp.			x		
silicoflagellates	x	x		x	x

Major species of diatoms in samples, xx=abundant, x= common

APPENDIX III

Illustrations of Species of Stratigraphic Importance, Southern Ocean Cretaceous - Present

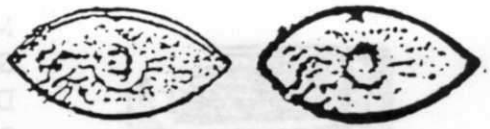
David Harwood

Upper Cretaceous (~70 Ma)
S.W. Pacific
DSDP Site 275
Sample 2-1, 103 cm
Hajos & Stradner, 1975

1. Actinoptychus packi

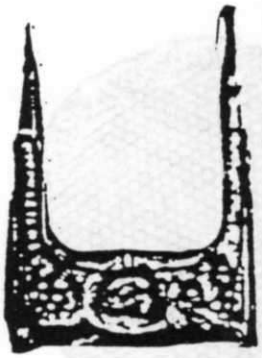
2. Cladogramma simplex

3. Acanthodiscus convexus



4. Chasea bicornis

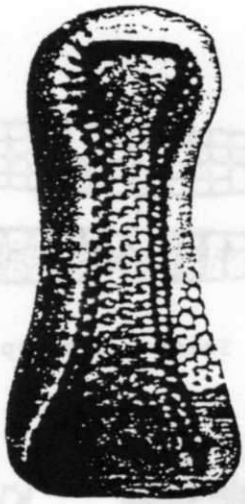
5. Chasea ornata



6. Hemiaulus danicus

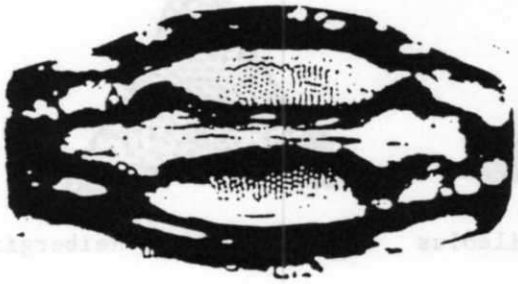
7. Pterotheca crucifera

8. Ceratulina cretacea

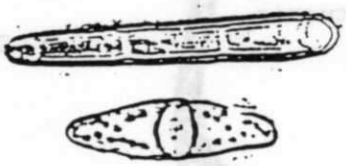


9. Gladiopsis pacifica

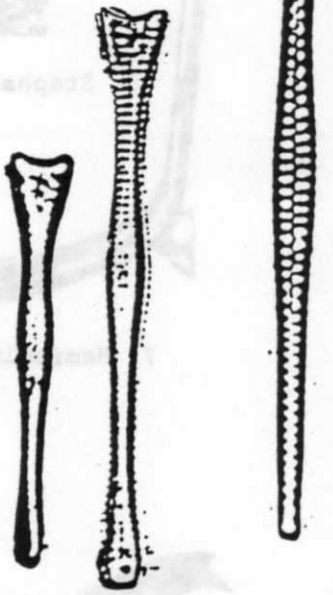
10. Gladiopsis jouseanus



11. Goniothecium odontella

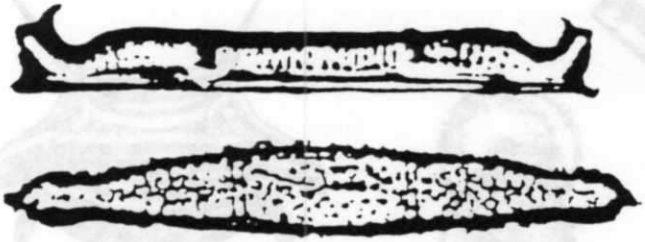


12. Huttonia spp.



13. Incisoria

14. Sceptroneis



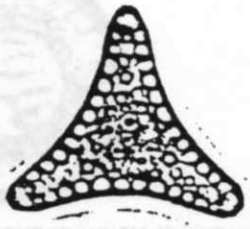
15. Hemiaulus gleseri

17. Trinacria incipiens

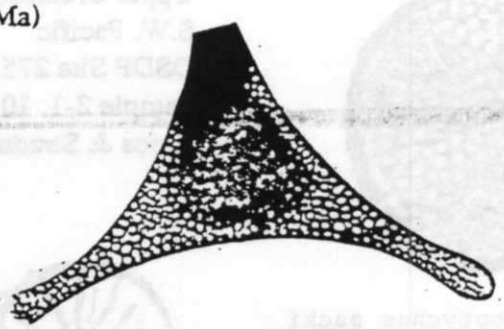
16. Hemiaulus kondai

Mid Paleocene (~63 Ma)
S.W. Pacific
DSDP Site 208
Sample 31-2, 101 cm

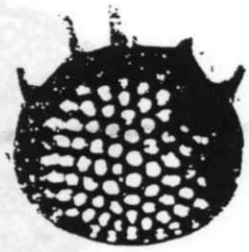
1. Hemiaulus rossicus



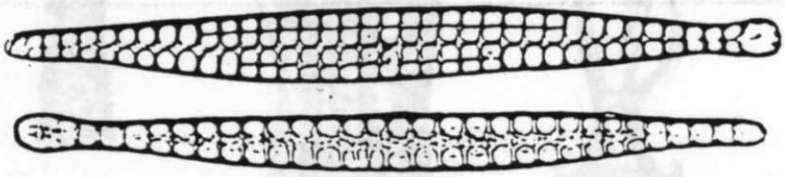
2. Trinacria nobile



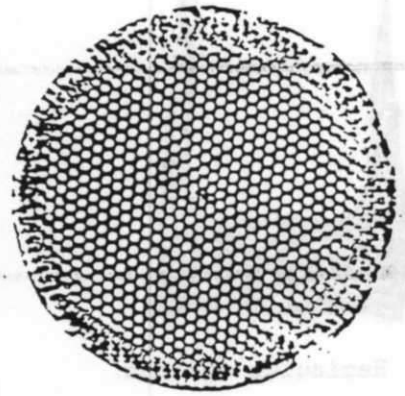
3. Triceratium (?)



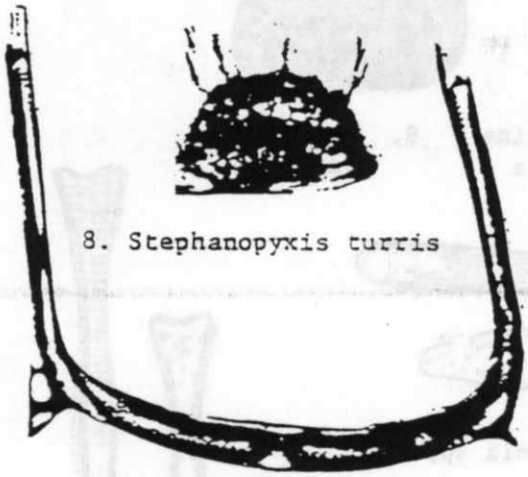
4. Stephanopyxis



5. Sceptroneis spp.

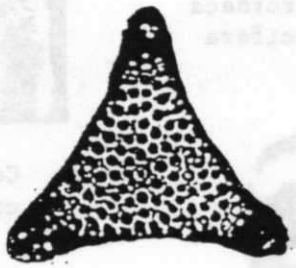


6. Thalassiosiropsis wittiana

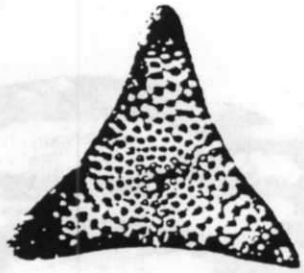


7. Hemiaulus peripterus

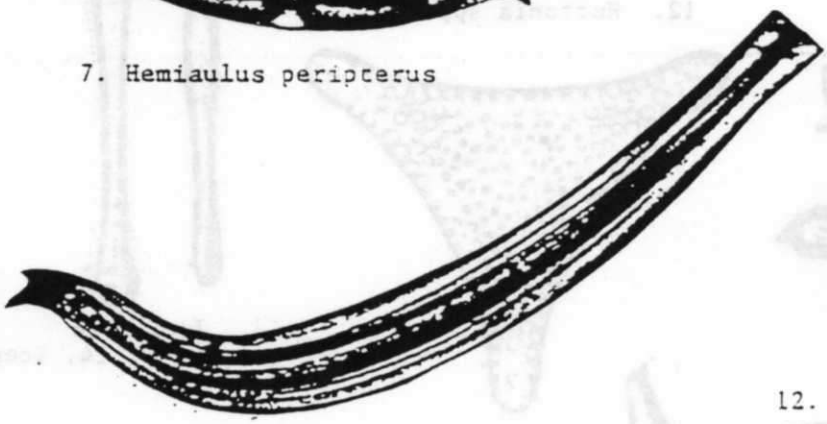
8. Stephanopyxis turris



9. Trinacria pileolus

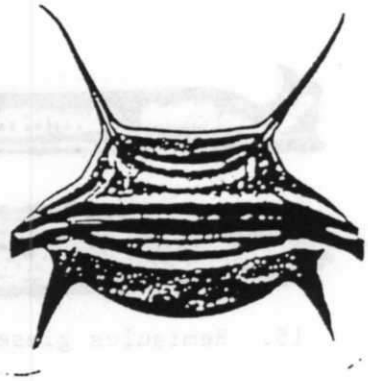


10. Trinacria heibergii



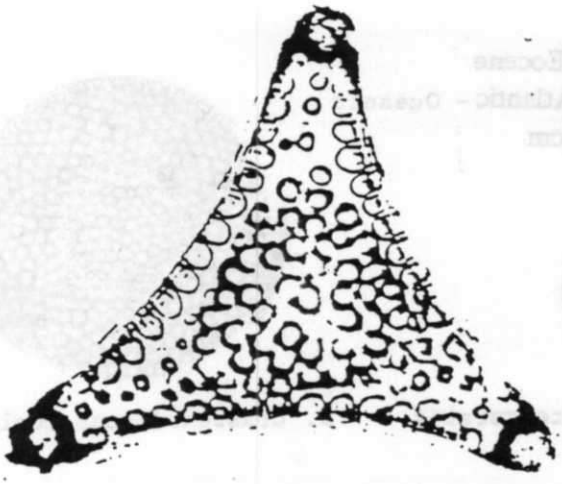
11. Rhizosolenia (?) cretacea

12. Trochosira

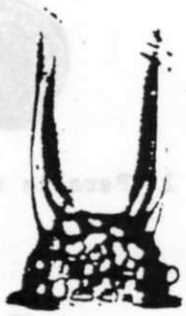


13. Odontropis klavensii

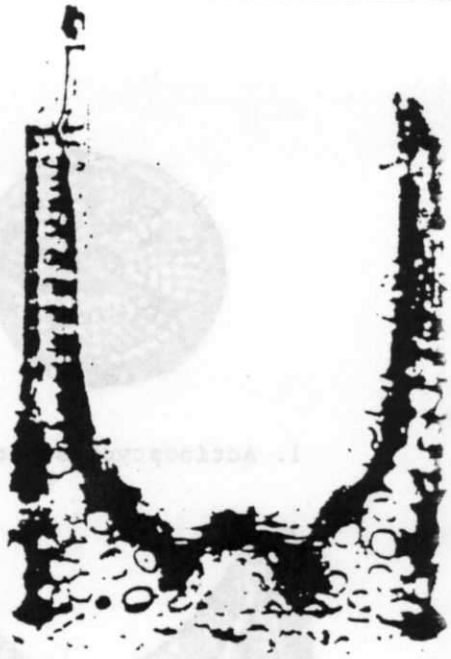
Upper Paleocene (~60 Ma)
South Atlantic-Oceanic
IO 1678-37, 390 cm
See Gombos, 1976



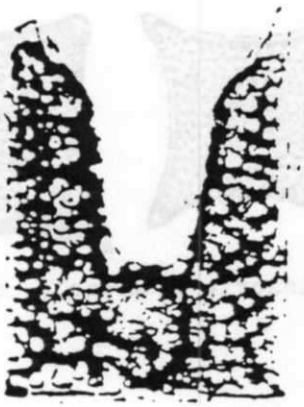
1. Trinacria pileolus



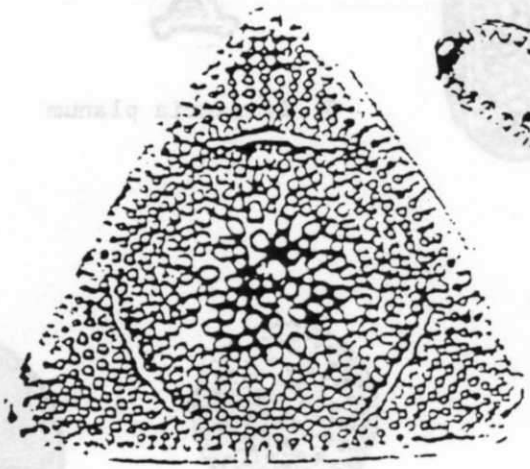
2. Stephanopyris superba var. bispinosa



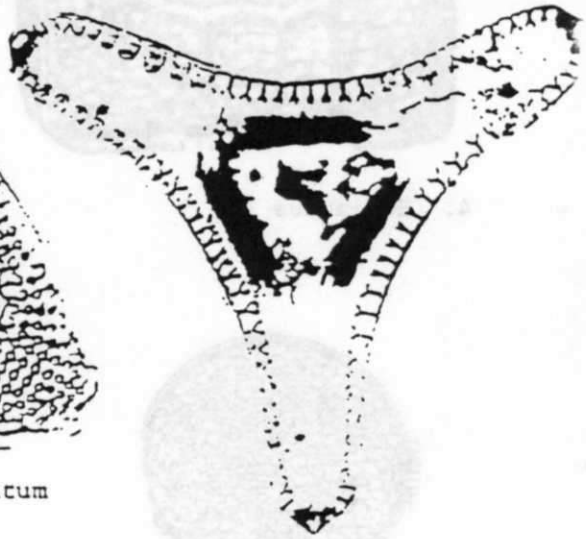
3. Hemiaulus polymorphus



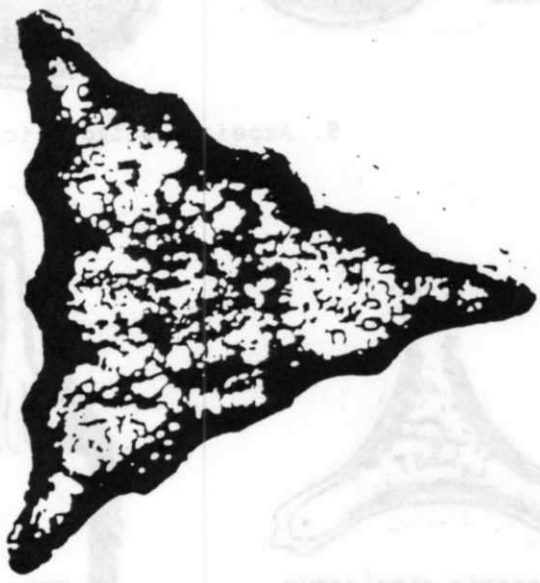
4. Hemiaulus incurvus



5. Triceratium cf. tessellatum



6. Trinacria simulacrum



7. Triceratium crenulatum

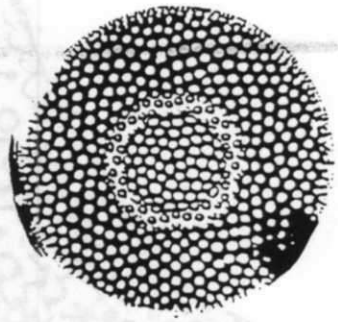
8. Hemiaulus altus

9. Hemiaulus inaequilateralis

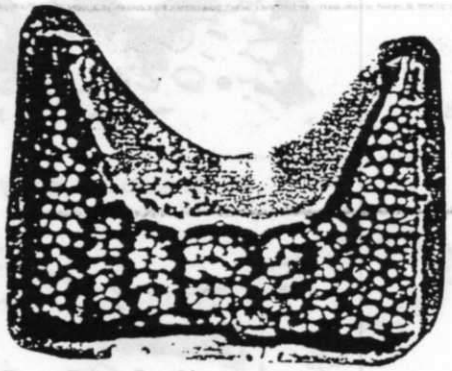
Middle to Upper Eocene
(~40 Ma) South Atlantic - Oceanic
IO 1678-44, 200 cm

1. Actinoptychus senarius

2. Paralia architecturalis

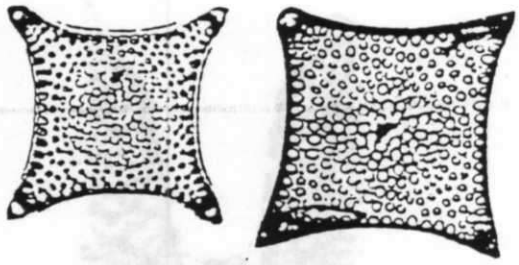


3. Craspedodiscus moelleri

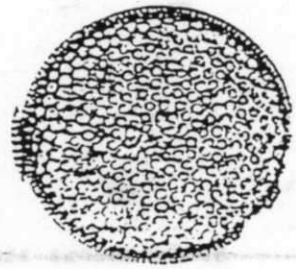


4. Hemiaulus sp.

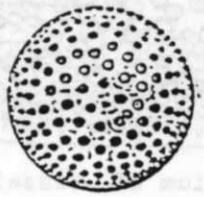
5. Trinacria planum



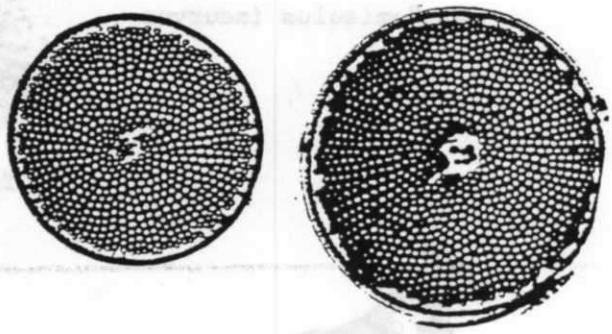
6. Trinacria excavata f. tetragona



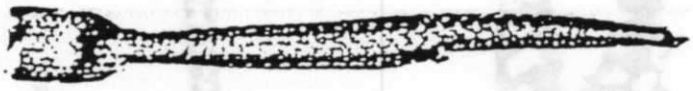
7. Coscinodiscus marginatus



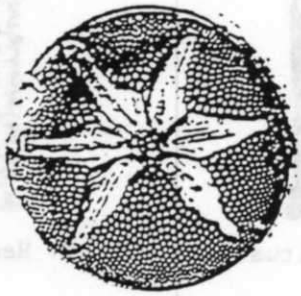
8. Rocella praenitida



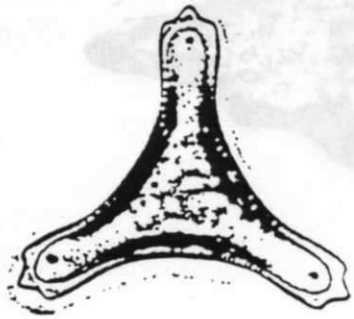
9. Azpeitia oligocenica



10. Pyxilla reticulata



10.5. Asterolampra uraster

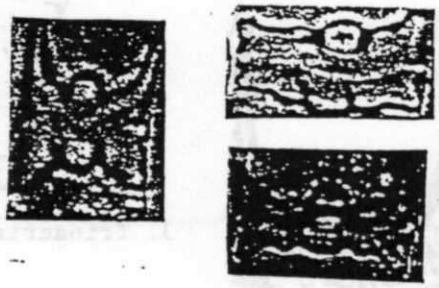


11. Trinacria simulacrum

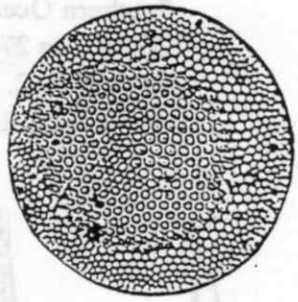
12. Pterotheca spp.

Lower Oligocene (~35 Ma)
McMurdo Sound, Antarctica-Shelf
CIROS-1
Sample 494.52 m
Harwood, 1989

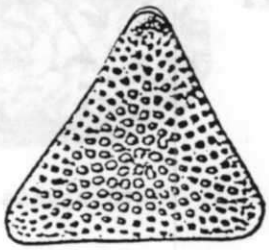
1. Hemiaulus caracteristicus



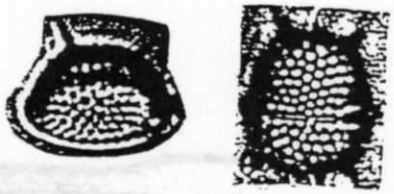
2. Hemiaulus dissimilis



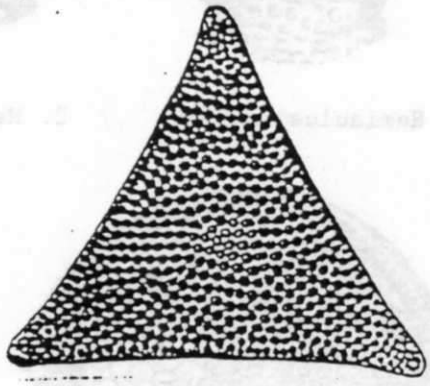
3. Stephanopyxis splendidus (resting spore)



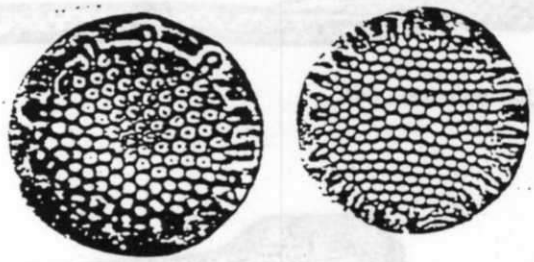
4. Triceratium polymorphus



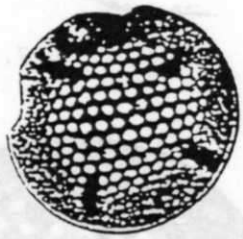
5. Stephanopyxis turris



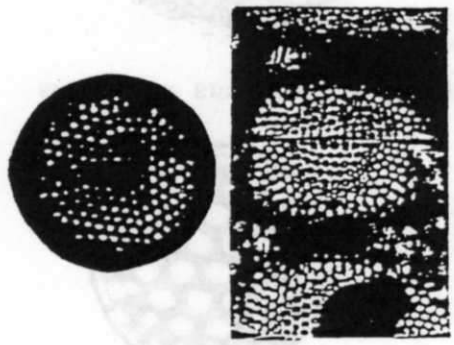
6. Pseudotriceratium radiosoreticulatum



7. Stephanopyxis superba (vegetative)



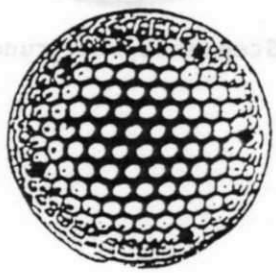
8. Stephanopyxis superba (resting spore)



9. Stephanopyxis ornamuensis

10. Pyxilla reticulata

11. Cotyledon fogedii

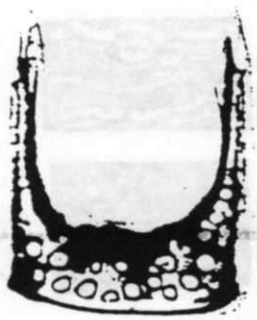


12. Stephanopyxis grunowii

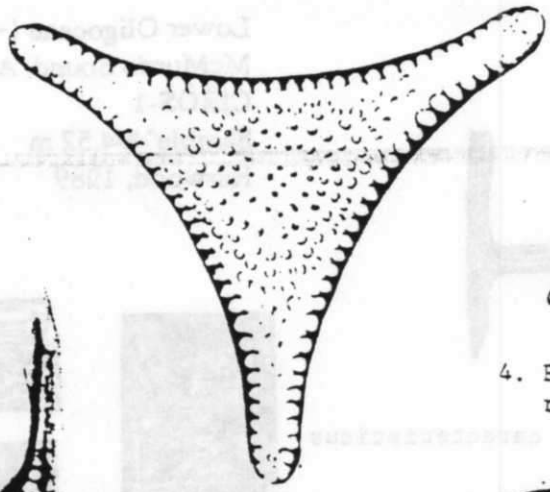
13. Kisseleviella carina

Lower Oligocene (~34 Ma)
Southern Ocean - S.W. Pacific
DSDP Site 274
Sample 31-2, 101 cm
McCollum, 1975

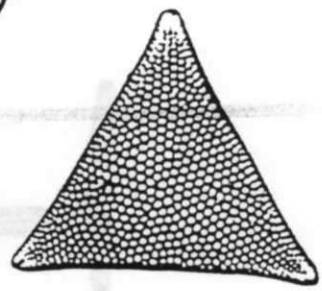
1. Hemiaulus incisus



2. Hemiaulus polycystinorum

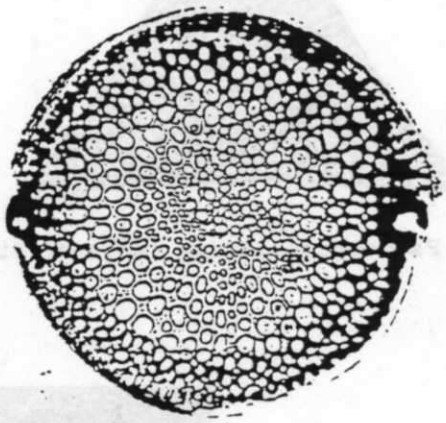


3. Trinacria excavata

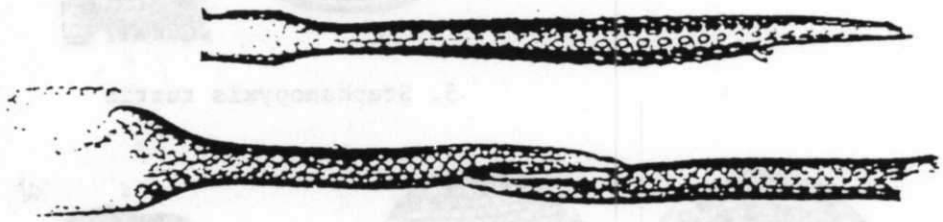


4. Pseudotriceratium radiosoreticulatum

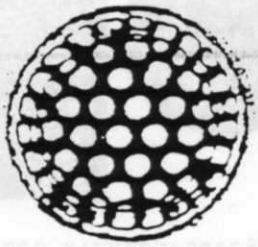
5. Xanthiopyxis acrolophra



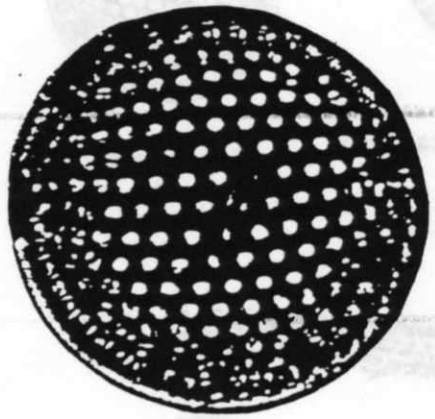
6. Sphynctolethus pacificus



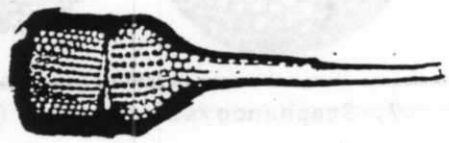
7. Pyxilla reticulata



8. Stephanopyxis

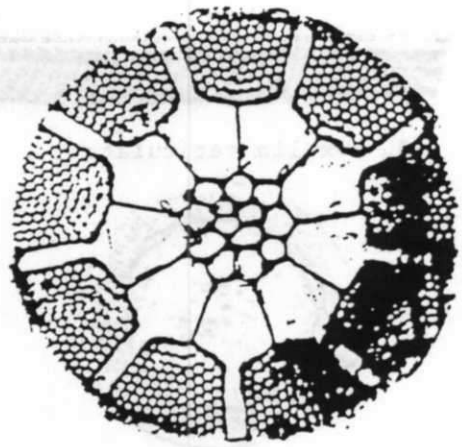


9. Stephanopyxis grunowii



10. Pyrgupyxis eocenica

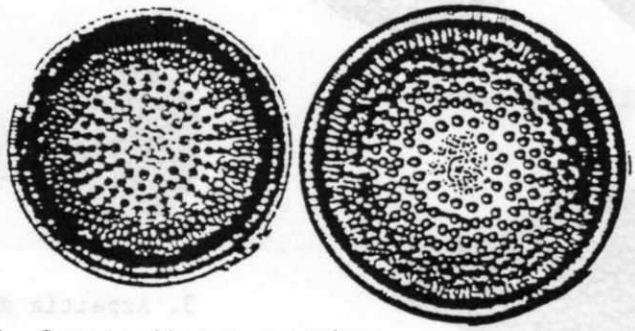
11. Hemiaulus characteristicus



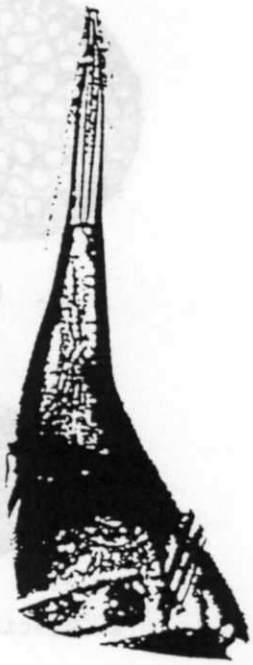
12. Asterolampra affinis

Lower Oligocene (~34 Ma)
South Atlantic
DSDP Site 513
Sample 30-4, 56 cm
Gombos & Ciesielski, 1983

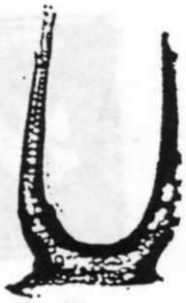
1. Hemiaulus polycystinorum



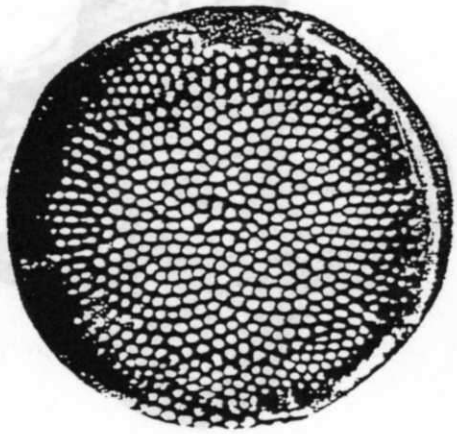
2. Coscinodiscus superbus



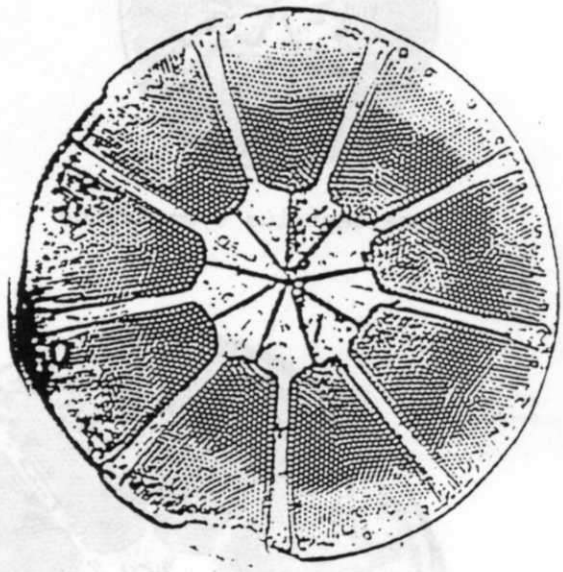
3. Rhizosolenia oligocaenica



4. Hemiaulus incisus



5. Coscinodiscus marginatus

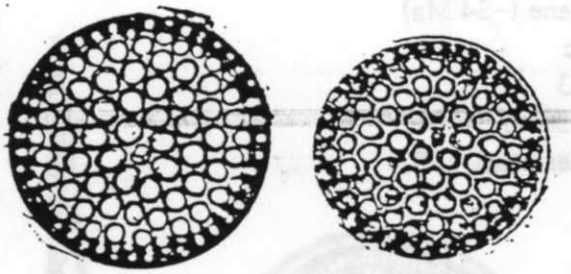


6. Asterolampra tela

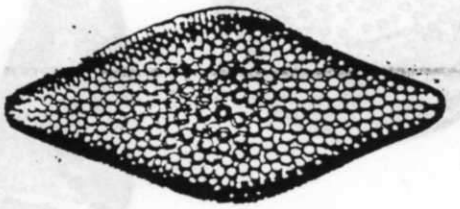
7. Sceptroneis sp.

8. Pyxilla reticulata

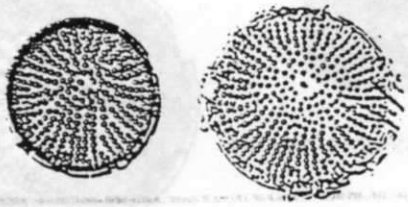
Upper Oligocene (~30 Ma)
South Atlantic
DSDP Site 513
Sample 17-5, 83 cm
Gombos & Ciesielski, 1983



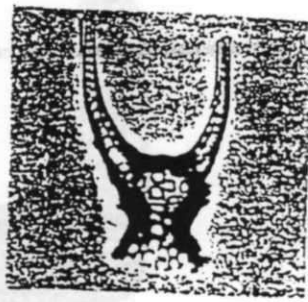
1. Rocella vigilans



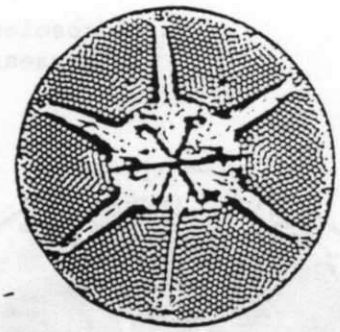
2. Coscinodiscus rhombicus



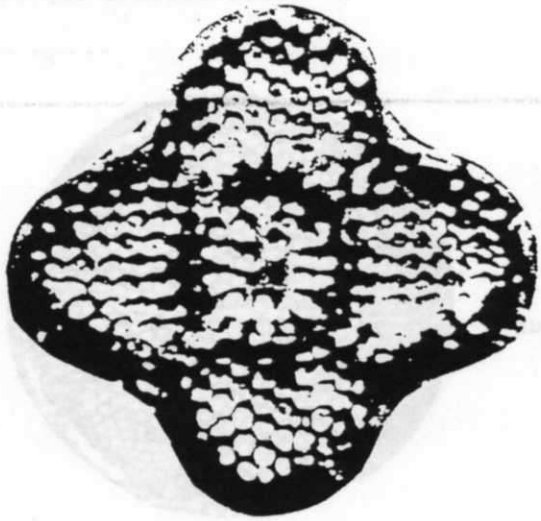
3. Azpeitia gombosi



4. Hemiaulus taurus

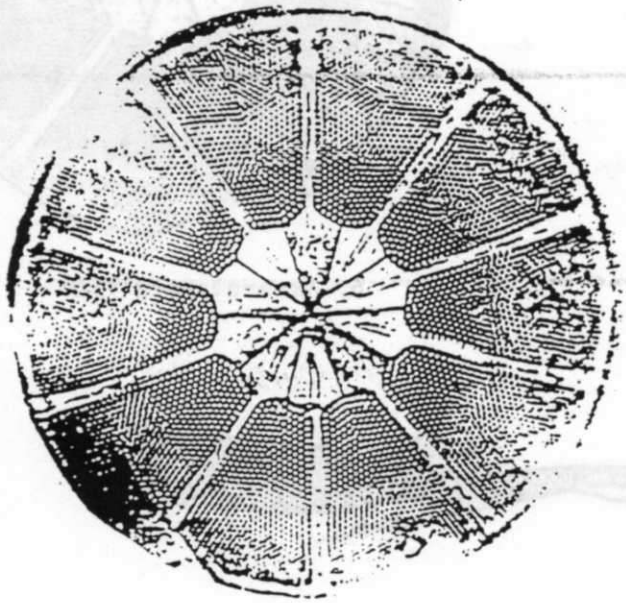


5. Asteromphalus symmetricus



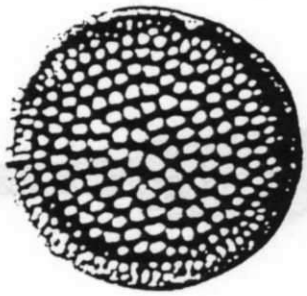
6. Lizitziana ornata

7. Skeletonema barbadense

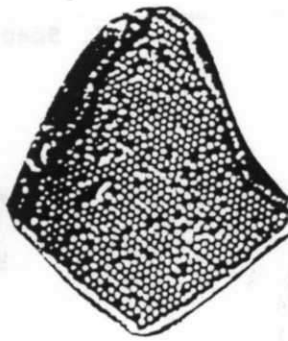


8. Asterolampra tela

9. Synodra jouseana

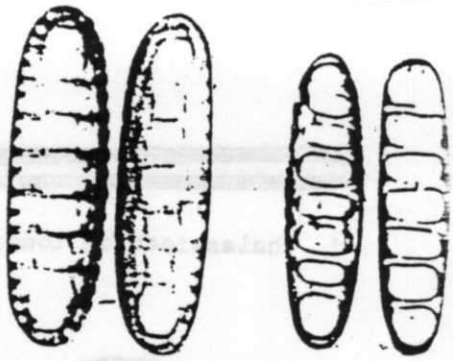


10. Coscinodiscus marginatus

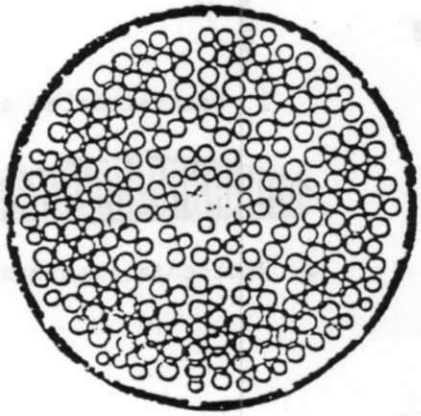


11. Ethmodiscus r

Middle Miocene (~11 Ma)
Kerguelen Plateau, S. Ocean
ODP Hole 751A
Sample 11-4, 105 cm
Harwood & Maruyama, 1992

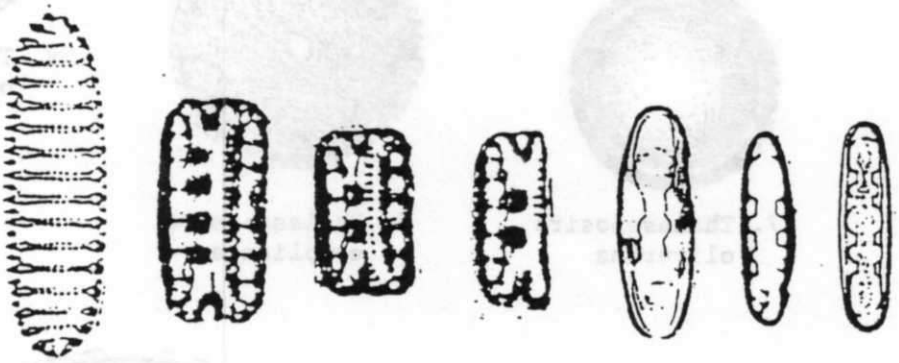


3. Denticulopsis dimorpha



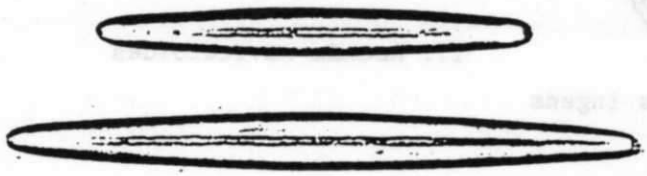
1. Azpeitia endoi

2. Nitzschia denticuloides



4. Denticulopsis praedimorpha

Lower Miocene (~16 Ma)
Kerguelen Plateau, S. Ocean
ODP Hole 751A
Sample 15-3, 105 cm
Harwood & Maruyama, 1992



2. Synedra jouseana

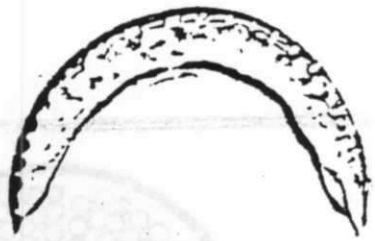
3. Coscinodiscus marginatus

1. Denticulopsis maccollumii

4. Raphidodiscus marylandicus

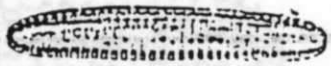
Lower Pliocene (~3.5 Ma)
Kerguelen Plateau, S. Ocean–Oceanic
ODP Hole 751A
Sample 3-4, 10 cm
Harwood & Maruyama, 1992

1. Thalassiothrix longissima



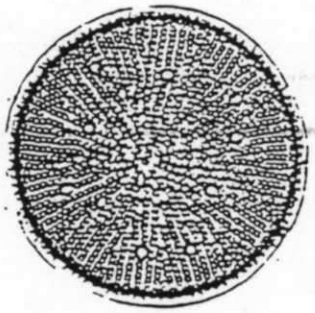
5. Dactyliosolen antarcticu

2. Nitzschia barronii



3. Nitzschia interfrigidaria

4. Nitzschia praeinterfrigidar

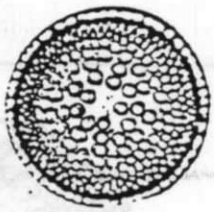


6. Thalassiosira vulnifica

7. Thalassiosira oliverana

8. Thalassiosira complicata

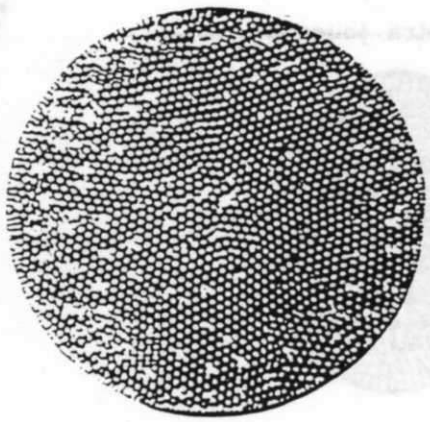
9. Thalassiosi oestrupii



10. Actinocyclus ingens

11. Rouxia naviculoides

12. Thalassiosira lentiginosa

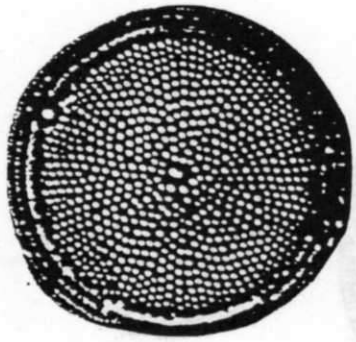


13. Thalassiosira striata

14. Thalassiosira mura

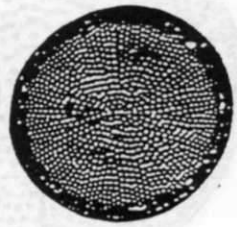
Upper Miocene (~6 Ma)
McMurdo Sound, Antarctica - SHELF
DVDP-11 drillhole
Sample 291.80 m
Harwood, 1986

1. Thalassiosira torokina

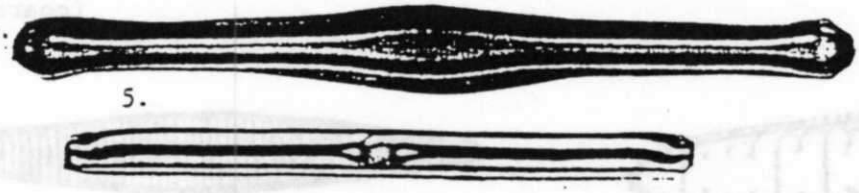


2. Actinocyclus octonarius

3. Diploneis sp



4. Actinocyclus octonarius

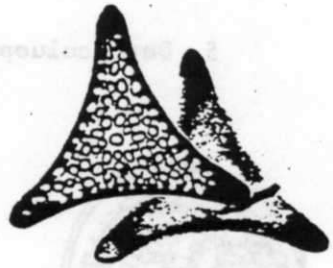


5.

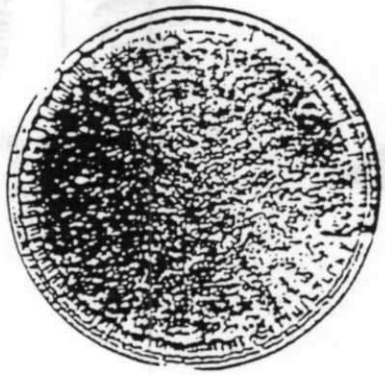
6. Grammatophora charcotii

7. Actinocyclus karstenii

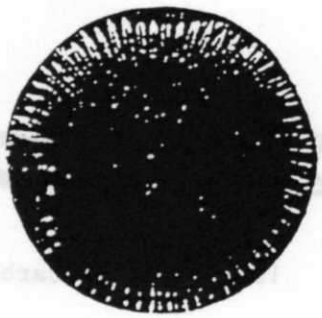
8. Cocconeis fasciolata



9. Trinacria pileolus



10. Paralia sol var marginalis



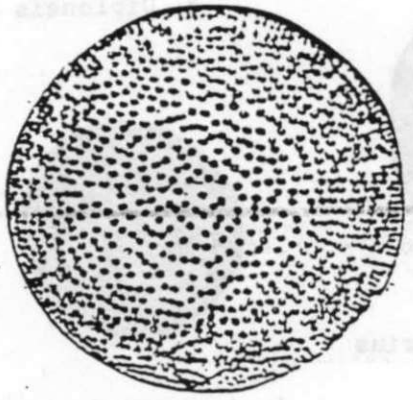
11. Paralia sol

12. Denticulopsis hustedtii

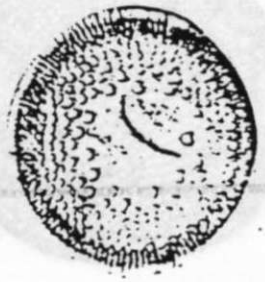
Upper Miocene (~6 Ma)
Kerguelen Plateau, S. Ocean--Oceanic
ODP Hole 751A
Sample 5-5, 10 cm
Harwood & Maruyama, 1992

1. Nitzschia praecurta

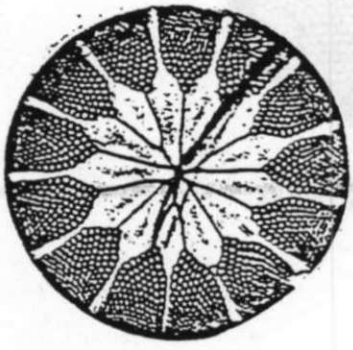
5. Thalassiosira miocenica



2. Actinocyclus karstenii



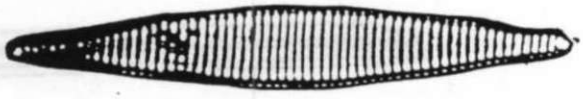
3. Hemidiscus ovalis



4. Asteromphalus kennettii

4.5. Thalassiosira oliverana (coarse)

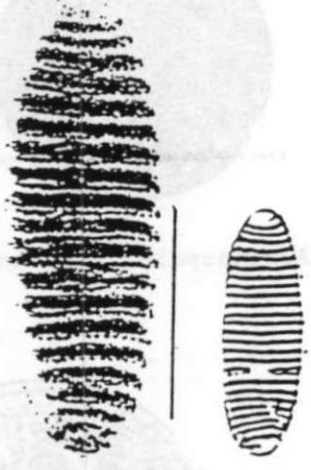
5. Denticuluopsis hustedtii



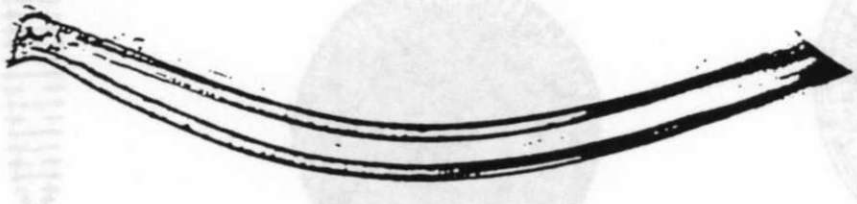
6. Nitzschia fossilis

7. Thalassiosira oliverana (var. sparsa)

8. Dactyliosolen antarcticus

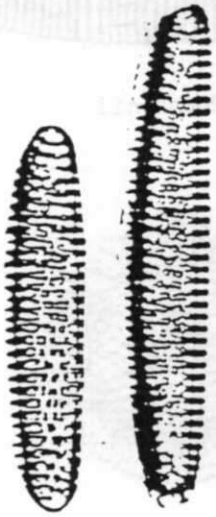


9. Nitzschia aurica



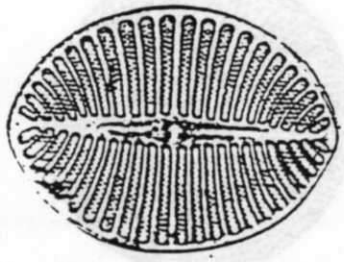
10. Proboscia barboi

Lower Pliocene (~3.2 Ma)
McMurdo Sound, Antarctica-SHELF
CIROS-2 drillhole
Sample 138.07 m
Harwood, 1986



1. Nitzschia interfrigidaria

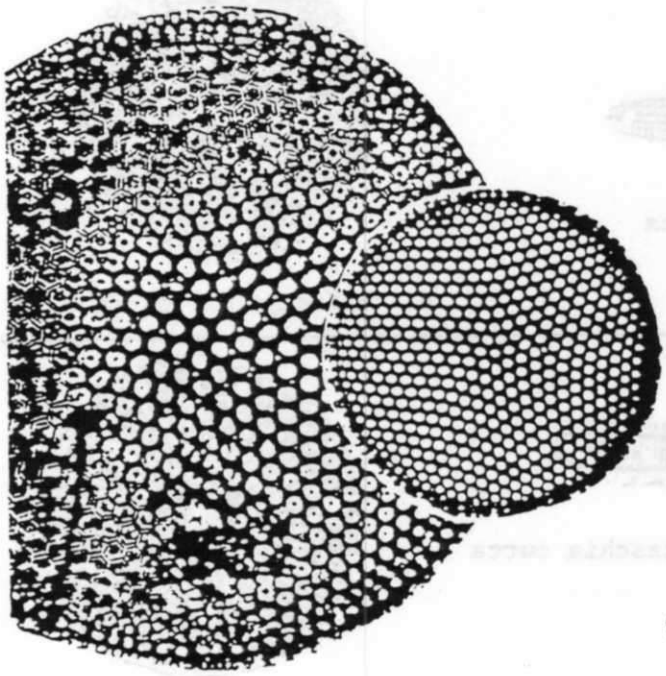
2. Grammatophora charcotii



3. Cocconeis pinnata

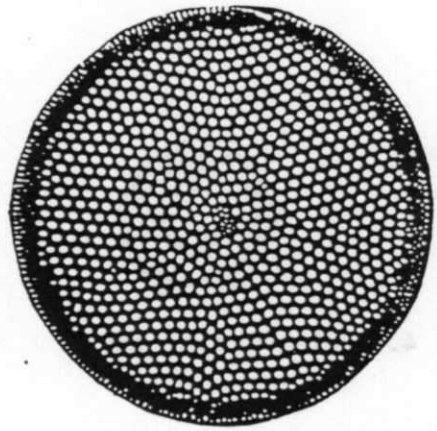
4. Actinocyclus karstenii

5. Nitzschia praecurta



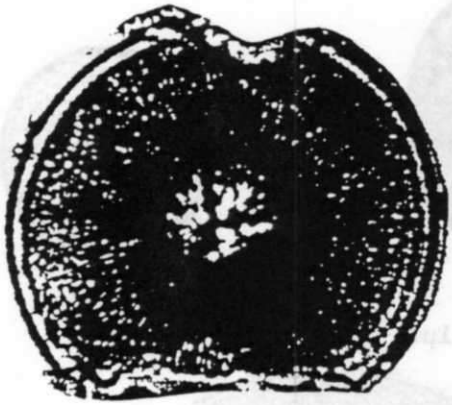
6. Thalassiosira kolbei

7. Th. inura

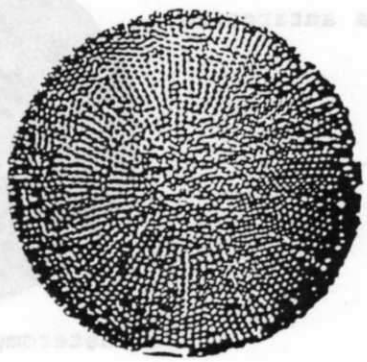


8. Thalassiosira torokina

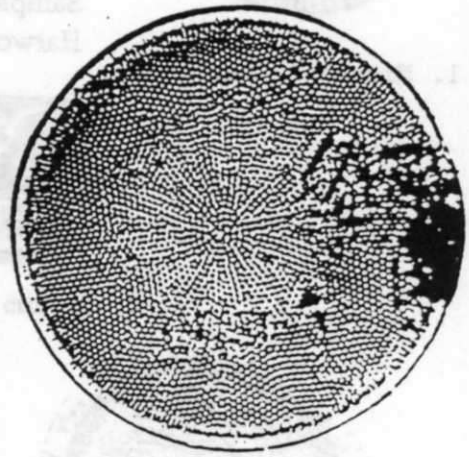
9. Eucampia antarctica



10. Stellarima microtrias



11. Thalassiosira fasciculata



12. Thalassiosira striata

Upper Pliocene (~3 Ma)
Kerguelen Plateau, S. Ocean - Oceanic
ODP Hole 751
Sample 2-2, 10 cm
Harwood & Maruyama, 1992

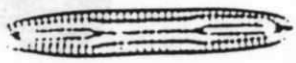
2.5 Nitzschia barronii

1. Hemidiscus karstenii

2. Thalassiosira vulnifica

3. Thalassiosira oliverana

4. Thalassiosira inura



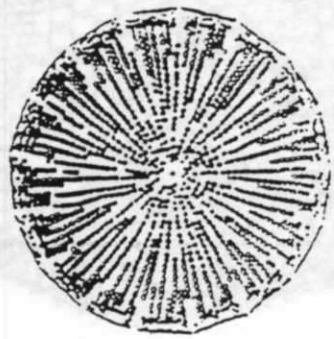
5. Rouxia antarctica

6. Actinocyclus fasciculata

Pleistocene (~1.5 Ma)
Kerguelen Plateau, S. Ocean
ODP Hole 751 - Oceanic
Sample 1-3, 10 cm
Harwood & Maruyama, 1992

1. Nitzschia barronii

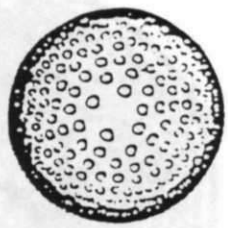
3. Nitzschia curta



4. Actinocyclus actinochilus

2. Eucampia antarctica

6. Asteromphalus parvulus



7. Actinocyclus inger

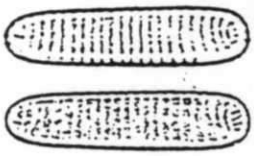
5. Thalassiosira oliverana

8. Nitzschia kerguelensis

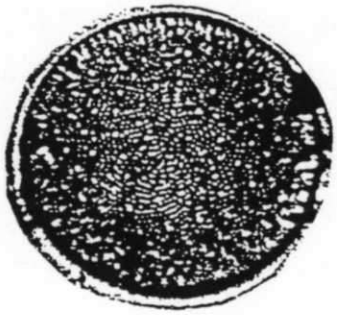
Pleistocene (< 0.5 Ma)
McMurdo Sound, Antarctica
CIROS-2 drillhole-SHELF
Sample -0.55 m
Harwood, 1986

1. Thalassiosira gracilis

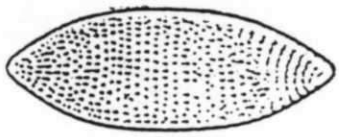
5. Eucampia antarctica



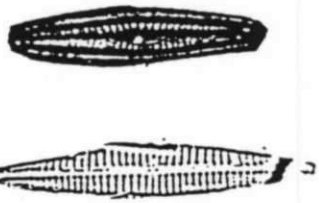
2. Nitzshia curta



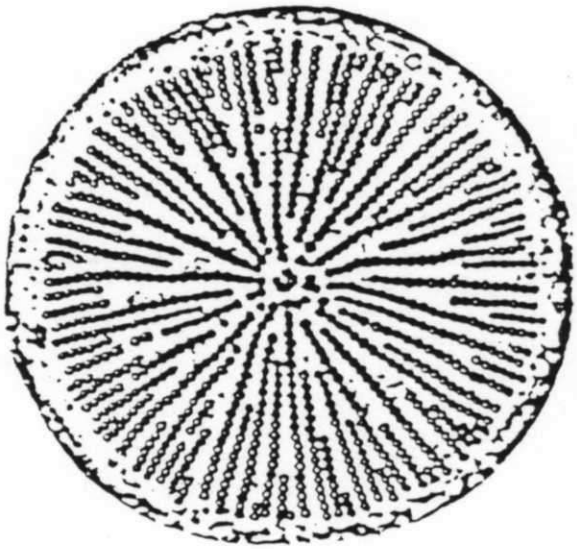
4. Porosira pseudodenticulata



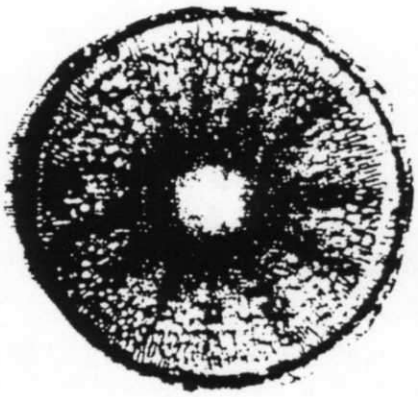
6. Nitzschia separanda



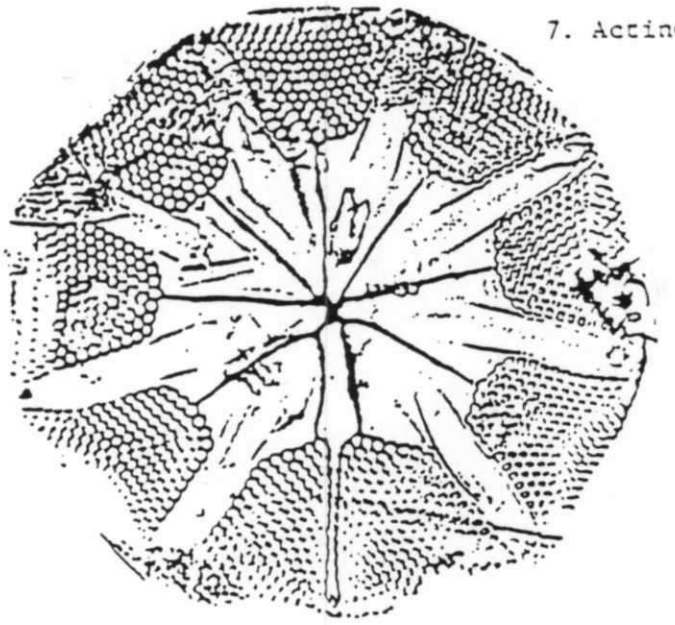
3. Navicula sp



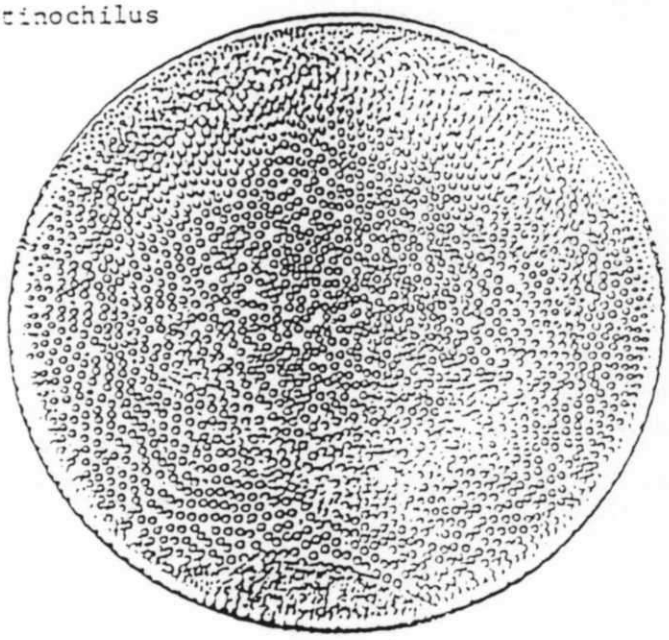
7. Actinocyclus actinochilus



8. Stellarima microtrias



9. Asteromphalus hookeri



10. Thalassiosira lentiginosa